LAKE CLASSIFICATION REPORT FOR WOLF LAKE, ADAMS COUNTY

Presented by Reesa Evans, Lake Specialist
Adams County Land & Water Conservation Department
P.O. Box 287, Friendship, WI 53934

JANUARY 2008

WOLF LAKE LAKE CLASSIFICATION REPORT
TABLE OF CONTENTS

EXECUTIVE SUMMARY

Background Information about Wolf Lake

Wolf Lake is located in Adams County in south central Wisconsin and is a 49-acre msesotrophic natural seepage lake located in the Town of Jackson, Adams County, in the Central Sands Area of Wisconsin. This lake has no stream inlet or outlet and fed by precipitation, runoff and groundwater. Wolf Lake is part of the Neenah Creek Watershed, a large watershed of 182 square miles from which water flows into the Fox River and eventually into Lake Michigan. Wolf Lake has a public boat ramp, but is designated as a no-motor lake for boat traffic. There are four Native American archeological sites located around Wolf Lake that cannot be further disturbed without permission of the federal government and input from the local tribes.

Except for some pockets of muck and silt loam, the soils in the surface and ground watersheds for Wolf Lake are loamy sand and sand, with slopes from very flat up to 25%. These soils tend to be well or excessively drained, no matter what the slope. Water, air and nutrients move through these soils at a rapid rate, so that little runoff occurs unless the soil becomes saturated. Wind erosion, water erosion and draught are common hazards of these soil types.

Land Use in Wolf Lake Watersheds

Both the surface and ground watersheds of Wolf Lake are fairly small.. Overall, the two most common current land uses in the Wolf Lake watersheds are woodlands and residences. In the surface watershed, non-irrigated agriculture is substantial. More than 1/3 of Wolf Lake's shore has wetlands at or near the shore that serve as filters and trappers that help keep the lake as clean as it is. Wetlands also play several important roles in maintaining water quality, in the aquatic food chain and in wildlife nesting. It is essential to preserve these wetlands for the health of Wolf Lake.

Wolf Lake has a total shoreline of 1.4 miles (7392 feet). About 1/3 of the northern shore is owned by the Wisconsin Department of Natural Resources and has been left unaltered. Included in that area are a bog and a sedge meadow. The balance of the shore consists of privately-owned lots and a boat ramp area owned by the Town of Jackson. Areas immediately at the shore are steeply sloped. Buildings are generally located 70 or more feet back from the shore.

A 2004 shoreline survey showed that most of Wolf Lake's shore is vegetated, either with native vegetation, mowed lawns or both. The 2004 inventory also classified shorelines has having "adequate" or "inadequate" buffers. An "adequate" buffer was defined as one having the first 35 feet landward covered by native vegetation. An "inadequate" buffer was anything that didn't meet the definition of "adequate buffer", including native vegetation strips less than 35 feet landward. 32.6% of Wolf Lake's shoreline had an "adequate buffer", leaving 67.4% as "inadequate."

Most of the "inadequate" buffer areas were found with traditional mowed lawns and/or insufficient native vegetation at the shoreline to cover 35 feet landward from the water line. Adequate buffers on Wolf Lake could be easily installed on most of the lake by either letting the first 35 feet landward from the water just grow without mowing it, except for a path to the water, or—if something more controlled or aesthetically pleasing was desired—by planting native seedlings sufficient to fill in the first 35 feet.

Water Testing Results

Between 2004 and 2006, Adams County Land & Water Conservation Department gathered water chemistry and other water quality information on 20 lakes in Adams County with public access. Wolf Lake was one of these lakes. Overall, Wolf Lake was determined to be a mesotrophic lake with very good water quality and excellent water clarity.

Measuring the phosphorus in a lake system thus provides an indication of the nutrient level in a lake. Increased phosphorus in a lake will feed algal blooms and also may cause excess plant growth. The 2004-2006 summer average phosphorus concentration in Wolf Lake was 17.3 micrograms/liter. This is below the 25 ug/l average for natural lakes in Wisconsin. This concentration suggests that Wolf Lake is likely to have few nuisance algal blooms. This places Wolf Lake in the "good" water quality section.

Water clarity is a critical factor for plants. If plants don't get more than 2% of the surface illumination, they won't survive. Water clarity is measured with a Secchi disk. Average summer Secchi disk clarity in Wolf Lake in 2004-2006 was 13.63 feet. This is very good water clarity. Records since 1990 show that the water clarity in Wolf Lake has consistently remained high.

Chlorophyll-a concentrations provide a measurement of the amount of algae in a lake's water. Algae are natural and essential in lakes, but high algal populations can increase water turbidity and reduce light available for plant growth, as well as result in unpleasing odor and appearance. The 2004-2006 summer (June-September) average chlorophyll concentration in Wolf Lake was 2.8 micrograms/liter, a low algal concentration. Chlorophyll-a averages have stayed low in Wolf Lake since 1992, the first year for which records were found.

Low dissolved oxygen levels during the summer in the bottom waters of a lake occurs naturally as oxygen in the bottom layer is consumed, but not replenished. As the summer progresses, the oxygen concentration of the bottom waters may decrease. In Wolf Lake, there were hypoxic (low oxygen) periods in the depths from 25' to 50' during the summers of 2004 and 2005. Besides being a potential danger to a lake's fish population, summer hypoxia can result in phosphorus being released into the upper water column and being available for algal blooms and increased aquatic plant growth. The data collected at Wolf Lake from 2004-2006 shows there is a potential for phosphorus loading from the lower depths (hypolimnion) during the summer months in Wolf Lake if the hypoxia/anoxia continues. Dissolved oxygen needs to be monitored during the late summer months in the lower depths on Wolf Lake to determine whether hypoxia/anoxia is a frequently-occurring condition that may need to be addressed by management practices.

Wolf Lake water testing results showed "hard" water (122 mg/l $CaCO_3$). Hard water lakes tend to produce more fish and aquatic plants than soft water lakes because they are often located in watersheds with soils that load phosphorus into the lake water. Hardness levels over 180 mg/l can cause marl to start precipitating out of the water or sediment, thus releasing phosphorus for aquatic plant and algae use. But since Wolf Lake's hardness less is far below that, the marl in the lake is likely to keep binding a significant amount of phosphorus that would otherwise be in the water column.

A lake with a neutral or slightly alkaline pH like Wolf Lake is a good lake for fish and plant survival. Natural rainfall in Wisconsin averages a pH of 5.6. This means that if the rain falls on a lake without sufficient alkalinity to buffer that acid water coming in by rainfall, the lake's fish cannot reproduce. That is not a problem at Wolf Lake.

Other water quality testing at Wolf Lake showed no particular areas of concern. The average calcium level in Wolf Lake's water during the testing period was 22.2 mg/l. The average Magnesium level was 14.74 mg/l. Both of these are low-level readings. The presence of a significant amount of chloride over a period of time may indicate that there are negative human impacts on the water quality present from septic system failure, the presence of fertilizer and/or waste, deposition of road-salt, and other nutrients. However, chloride levels found in Wolf Lake during the testing period were all below 3 mg/l, at about the natural level of chloride in this area of Wisconsin. Nitrogen levels can affect other aspects of water quality. The sum of water testing results for nitrate, nitrite and ammonium levels of over .3 mg/l in the spring can be used to project the likelihood of an algal bloom in the summer (assuming sufficient phosphorus is also present). Wolf Lake combination spring levels from 2004 to 2006 never rose to more than .13 mg/l, far below the .3 mg/l predictive level.

Both sodium and potassium levels in Wolf Lake are very low: the average sodium level was 1.98 mg/l; the average potassium reading was .13 mg/l. To prevent the formation of H2S, levels of 10 mg/l are best. A health advisory kicks in at 30 mg/l. Wolf Lake sulfate levels average 3.61 mg/l during the testing period, far below either level. Turbidity reflects water clarity. The term refers to suspended solids in the water column—solids that may include clay, silt, sand, plankton, waste, sewage and other pollutants. Very turbid waters may not only smell and mask bacteria & other pollutants, but also tend to be aesthetically displeasing, thus curtailing recreational uses of the water. Turbidity levels for Wolf Lake's waters were all at very low levels.

<u>Phosphorus</u>

Like most lakes in Wisconsin, Wolf Lake is a phosphorus-limited lake: of the pollutants that end up in the lake, the one that most affects the overall quality of the lake water is phosphorus. The amount of phosphorus especially affects the frequency and density of aquatic vegetation and the frequency and density of various kinds of algae, as well as water clarity and other quality aspects.

The total phosphorus (TP) concentration in a lake is considered a good indicator of a lake's nutrient status, since the TP concentration tends to be more stable than other types of phosphorus concentration. For a natural lake like Wolf Lake, a total phosphorus concentration below 20 micrograms/liter tends to prevent nuisance algal blooms. Wolf Lake's growing season (June-September) surface average total phosphorus level of 17.3 micrograms/liter is low enough so that nuisance algal blooms should occur only rarely.

In most lakes in Wisconsin, phosphorus concentration in the bottom sediments of the lake is considerably higher than the concentration in the water column itself. Bottom sediments can "bind up" phosphorus, making it unavailable for aquatic plants or algae to use. Some sediment types hold phosphorus at a higher rate than others. Wolf Lake is lucky to have a substantial amount of marl in its sediments. "Marl" is a calcium carbonate precipitate (solid) that forms in hardwater lakes when both calcium and pH levels are high and has a high capacity to immobilize phosphorus and other nutrients. With such a large amount of marl sediment, Wolf Lake may benefit from it removing phosphorus from water column, thus making it unavailable for algal and aquatic plant growth.

A review of historical data before the most recent aquatic plant survey suggested that nutrients in Wolf Lake have increased over the years. Testing for phosphorus in the lower depths of Wolf Lake suggests that the lower water depths may be accumulating phosphorus, added to that accumulating in the sediments. This situation should be monitored.

Land use plays a major role in phosphorus loading. The land uses around Wolf Lake that contribute the most phosphorus are non-irrigated agriculture and residences. Some phosphorus deposition cannot be controlled by humans. However, some phosphorus (and other nutrient) input can be decreased or increased by changes in human land use patterns. Practices such as shoreland buffer restoration; infiltrating stormwater runoff from roof tops, driveways and other impervious surfaces; using no phosphorus lawn fertilizers; and reducing phosphorus input to and properly managing septic systems will minimize phosphorus inputs into the lake.

Reducing the amount of input from the surface and ground watersheds results in less nutrient loading into the lake itself. Under modeling predictions, reducing phosphorus inputs from human-based activities even 10% would improve Wolf Lake water quality by 1 to 2 micrograms of phosphorus/liter; a 25% reduction would save 2 to 4 micrograms/liter. Currently, both the spring turnover and summer phosphorus levels are below the threshold value of 20 micrograms/liter, but a phosphorus increase from human activities of only 25% would put the phosphorus levels in the lake over that threshold in the summer. The result would be more algal blooms and more aquatic plants. Decreases would reduce those problems. The modeling predictions make it clear that reducing current phosphorus human-impacted inputs to the lake are essential to improve, maintain and protect Wolf Lake's health for future generations.

Aquatic Plant Community

The aquatic plant community of Wolf Lake is characterized by high quality and excellent species diversity. The plant community suggests that Wolf Lake is closer to an undisturbed condition than the average lake in the state. In the North Central Hardwoods Region, Wolf Lake is in the group of lakes closest to an undisturbed condition.

The Wolf Lake aquatic plant community has colonized 100% of the littoral zone and about half the lake. The 0-1.5' depth supported the most abundant aquatic plant growth. The co-dominant species in Wolf Lake were *Chara* spp (muskgrass, a plant-like algae) and *Elodea canadensis* (common waterweed). Sub-dominant was *Najas guadelupensis* (Southern naiad).

Myriphyllum spicatum (Eurasian watermilfoil), an aggressive invasive species, was introduced to Wolf Lake in the early 2000s. The lake association started using spot chemical treatments to manage this plant in 2002, resulting in a decline of the overall population of Eurasian watermilfoil from 9.5 acres to less than 5 acres. The most recent (2005) aquatic plant survey showed the plant still present, but at below average densities and only in the depths over 10'. In addition, a survey in 2007 indicated that the native weevil, *Euhrychiopsis lecontei*, was present in parts of Wolf Lake. This weevil, if present in sufficient density, can weaken Eurasian milfoil plants to the point of death.

Critical Habitat Areas

Wisconsin Rule 107.05(3)(i)(I) defines a "critical habitat areas" as: "areas of aquatic vegetation identified by the department as offering critical or unique fish & wildlife habitat or offering water quality or erosion control benefits to the body of water. Thus, these sites are essential to support the wildlife and fish communities. They also provide mechanisms for protecting water quality within the lake, often containing high-quality plant beds. Finally, critical habitat areas often can provide the peace, serenity and beauty that draw many people to lakes. Two areas on Wolf Lake were determined by a team of lake professionals to be appropriate for critical habitat designation.

WL1 extends along approximately 425 feet of the southeastern shoreline of Wolf Lake, up to the ordinary high water mark. With only a little human disturbance along this shoreline, the area has natural scenic beauty. This area includes three types of aquatic plants: emergents; floating-leaf; and submergent. Emergents provide important fish habitat and spawning areas, as well as food and cover for wildlife. Floating-leaf plants provide cover for fish and invertebrates, as well as help dampen waves to protect the shore. Eighteen species of native submergent plants were also at this site. Such a diverse aquatic plant community provides many benefits.

WL2 extends along approximately 1900 feet of the northern shoreline and landward from the shore to cover the deep marsh and sedge meadow wetlands located near the shore. With no human disturbance along this shoreline, the area is has natural scenic beauty. A pair of eagles has nested here for the past several years. Frogs were heard. Downed logs serving as habitat were also seen. Upland wildlife feed and nest here as well. Since human disturbance is absent in WL2, it provides high-quality habitat for many types of wildlife. Aquatic plants at this site included emergent species, 3floating-leaf rooted plants and submergent plants.

Fish/Wildlife/Endangered Resources

A 1963 fish inventory found both largemouth bass and bluegills abundant, with pumpkinseed also common. Rock bass, black crappie and green sunfish were present, but not in great numbers. Yellow perch were scarce. By 1973, yellow perch, black crappie and green sunfish were found in greater numbers, but pumpkinseed and rock bass had become scarce, as were brown bullheads and northern pike. Largemouth bass and bluegills continued to be found in large numbers. Inventories repeated in 1982 and 1996 noted this trend continued: largemouth bass and bluegill found in great numbers, but bullheads, perch, rockbass and pumpkinseed still scarce.

Fish cribs were installed in the lake in 1997 to encourage reproduction. Red Banded Killifish (*Fundulus diaphanous*) was the only endangered or threatened species reported around or in Wolf Lake. It was reported as scarce in a 1996 fish survey.

Muskrat and mink are also known to use this habitat for cover, reproduction and feeding. Seen during the field survey were various types of waterfowl, songbirds, and turkey. Frogs and salamanders are known to use this area for shelter/cover, nesting and feeding. Turtles and snakes also use this area for cover or shelter in this area, as well as nested and fed in this area. Sandhill cranes have also nested on Wolf Lake. Upland wildlife feed and nest here as well.

Conclusion

Wolf Lake is currently a fairly healthy, well-managed lake with many positive aspects, as discussed in this report. The main foci of continued management should include shoreland restoration, integrated management of invasive species, reduction of human-impacts on phosphorus loading, well-managed land use and continued monitoring for water quality and invasive species. Care should be taken to maintain the overall excellent quality of the lake and its surroundings.

It is hoped that the recommendations on the following pages will help in these aims.

RECOMMENDATIONS

Lake Management Plan

Wolf Lake does not currently have a lake management plan. Until the conclusion of this lake classification study, the information necessary to write such a plan was not available. It is anticipated that by the end of 2008, if not sooner, the Wolf Lake Association, with the assistance of the Adams County Land & Water Conservation Department, will have developed a plan.

This plan will need to include the following aspects concerning the management of the lake (and probably others): aquatic plant management; control/management of invasive species; wildlife and fishery management; watershed management; shoreland protection; critical habitat protection; water quality protection.

Watershed Recommendations

Although neither the surface nor ground watershed for Wolf Lake is particularly large, results of the modeling certainly suggests that input of nutrients, especially phosphorus, are a factor that needs to be explored for Wolf Lake.

Therefore, it is recommended that both the surface and ground watersheds be inventoried, documenting any of the following: runoff from any livestock operations that may be entering the surface water; soil erosion sites; agricultural producers not complying with nutrient management plans and/or irrigation water management plans.

If such sites are documented, steps for dealing with these issues can be incorporated into the lake management plan to be completed by the end of 2008.

Aquatic Plant/Aquatic Invasive Species/Shoreland Recommendations

Based on the 2005 aquatic plant survey and the 2004 shoreland survey, the following recommendations are made concerning aquatic plants and aquatic invasive species:

1) All lake residents should practice best management on their lake properties, including keeping septic systems cleaned and in proper condition, eliminating the use of lawn fertilizers, cleaning up pet wastes and not composting near the water.

2) Residents should continue involvement in the Citizen Lake Water Monitoring Program, Invasive Species Monitoring and Clean Boats, Clean Waters. This will allow not only noting changes in the Eurasian Watermilfoil pattern, but also those for Curly-Leaf Pondweed and Purple Loosestrife. Noting the presence and density of these plants early is the best way to take preventive action to keep them from becoming a bigger problem.

3) Lake residents should protect and restore natural shoreline around Wolf Lake. The lower frequency and density of the most sensitive plant species in the disturbed shoreline areas is evidence that shore disturbance is impacting the aquatic plant community of the lake. Disturbed shoreline sites support an aquatic plant community that has been less able to resist invasions of exotic species and shows impacts from nutrient enrichment.

4) All lake users should protect the aquatic plant community in Wolf Lake.

5) The Wolf Lake Association should maintain exotic species signs at the boat landings and contact DNR if the signs are missing or damaged.

6) The Wolf Lake Association should continue monitoring and control of Eurasian Watermilfoil maintain the most effective methods and modify if necessary. Early-season treatments with a specific chemical should be continued as long as it remains effective. The Lake Association should investigate ways to increase treatment effectiveness in the deeper water. Residents may need to hand-pull scattered plants.

7) Consideration should be given to propagating the native weevil that attacks Eurasian Watermilfoil to assist in EWM management.

Critical Habitat Recommendations

There are also several recommendations appropriate for the critical habitat areas.

(1) Maintain current habitat for fish and wildlife.
(2) Do not remove fallen trees along the shoreline nor logs in the water.
(3) No alteration of littoral zone unless to improve spawning habitat.
(4) Seasonal protection of spawning habitat.
(5) Maintain snag/cavity trees for nesting.
(6) Maintain or increase wildlife corridor.
(7) Maintain sedge meadow and deep marsh areas.
(8) Maintain no-wake zone.
(9) Protect emergent vegetation for habitat and shoreline protection.
(10) Removal of submergent vegetation for navigation purposes only.
(11) Seasonal control of Eurasian Watermilfoil and Curly-Leaf Pondweed by using control methods specific for exotics.
(12) Minimize aquatic plant and shore plant removal to maximum 30' wide access/viewing corridor. Leave as much vegetation as possible to protect water quality and habitat.
(13) Use forestry best management practices.
(14) No use of lawn products.
(15) No bank grading or grading of adjacent land.
(16) No pier construction or other activity except by permit using a case-by-case evaluation.
(17) No installation of pea gravel or sand blankets.
(18) No bank restoration unless the erosion index scores moderate or high.
(19) If the erosion index does score moderate or high, bank restoration only using biologs or similar bioengineering, with no use of riprap or retaining walls.
(20) Placement of swimming rafts or other recreational floating devices only by permit.
(21) Maintain buffer of shoreline vegetation.
(22) Maintain aquatic vegetation in undisturbed condition for wildlife habitat, fish use and water quality protection.
(23) Post landing with exotic species alert and educational signs to prevent introduction and/or spread of exotic species.
(24) Maintain no motor designation.

LAKE CLASSIFICATION REPORT FOR WOLF LAKE, ADAMS COUNTY

INTRODUCTION

In 2003, The Adams County Land & Water Conservation Department (Adams County LWCD) determined that a significant amount of natural resource data needed to be collected on the lakes with public access in order to provide it and the public with information necessary to manage the lakes in a manner that would preserve or improve water quality and keep it appropriate for public use. In some instances, there was significant historical data about a particular lake; in that instance, the study activities concentrated on combining and updating information. In other instances, there was no information on a lake, so study activities concentrating on gathering data about that lake. Further, it was discovered that information was scattered among various citizens, so often what information was actually available regarding a particular lake was unknown. To assist in updating some information and gathering baseline information, plus centralize the data collected, so the public may access it. The Adams County LWCD received a series of grants from the Wisconsin Department of Natural Resources (WDNR) from the Lake Classification Grant Program.

Objectives of the study were:

- collect physical data on the named lakes to assist in assessing the health of Adams County lake ecosystems and in classifying the water quality of the lakes.
- collect chemical and biological data on the named lakes to assist in assessing the health of Adams County lake ecosystems and in classifying the water quality of the lakes.
- develop a library of lake information that is centrally located and accessible to the public and to City, County, State and Federal agencies.
- make specific recommendations for actions and strategies for the protection, preservation and management of the lakes and their watersheds.
- create a baseline for future lake water quality monitoring.
- Provide technical information for the development of comprehensive lake management plans for each lake
- provide a basis for the water quality component of the Adams County Land and Water Resource Management Plan. Components of the plan will be incorporated into Adams County's "Smart Growth Plan".
- develop and implement educational programs and materials to inform and education lake area property owners and lake users in Adams County.

METHODS OF DATA COLLECTION

To collect the physical data, the following methods were used:

- delineation & mapping of ground & surface watersheds using topographic maps, ground truthing and computer modeling;
- identification of flow patterns for both the surface & ground watersheds using known flow maps and topographic maps;
- inventory & mapping of current land use with orthographic photos and collected county information;
- inventory & mapping of shoreline erosion and buffers using county parcel maps and visual observation;
- inventory & mapping for historical and cultural sites using information from the local historical society and the Wisconsin Historical Society;
- identification & mapping of critical habitat areas with WDNR and Adams County LWCD staff;
- identification & mapping of endangered or threatened natural resources (including natural communities, plant & animal species) using information from the Natural Heritage Inventory of Wisconsin;
- identification & mapping of wetland areas using WDNR and Natural Resource Conservation Service wetland maps;
- preparation of soil maps for each of the lake watersheds using soil survey data from the Natural Resource Conservation Service.

To collect water quality information, different methods were used:

- for three years, lakes were sampled during late winter, at spring and fall turnover, and several times during the summer for various parameters of water quality, including dissolved oxygen, relevant to fish survival and total phosphorus, related to aquatic plant and algae growth;
- random samples from wells in each lake watershed were taken in two years and tested for several factors;
- aquatic plant surveys were done on all 20 lakes and reports prepared, including identification of exotics, identifying existing aquatic plant community, evaluation of community measures, mapping of plant distribution, and recommendations;
- all lakes were evaluated for critical habitat areas, with reports and recommendations being made to the respective lakes and the WDNR;
- lake water quality modeling was done using data collected, as well as historical data where it was available.

WATER QUALITY COMPUTER MODELING

Wisconsin developed a computer modeling program called WiLMS (Wisconsin Lake Modeling Suite) to assist in determining the amount of phosphorus being loaded annually into a lake, as well as the probable source of that phosphorus. This suite has many models, including Lake Total Phosphorus Prediction, Lake Eutrophic Analysis Procedure, Expanded Trophic Response, Summary Trophic Response, Internal Load Estimator, Prediction & Uncertainty Analysis, and Water & Nutrient Outflow. The models that various types of data inputs: known water chemistry; surface area of lake; mean depth of lake; volume of lake; land use types & acreage. This information is then used in the various models to determine the hydrologic budget, estimated residence time, flushing rate, and other parameters.

Using the data collected over the course of the studies, various models were run under the WiLMS Suite. These water quality models are computer-based mathematical models that simulate lake water quality and watershed runoff conditions. They are meant to be a tool to assist in predicting changes in water quality when watershed management activities are simulated. For example, a model might estimate how much water quality improvement would occur if watershed sources of phosphorus inputs were reduced. However, it should be understood that these models predict only a <u>relative</u> response, not an exact response. Modeling results will be incorporated into topic discussions as appropriate.

DISSEMINATION OF PRODUCT DELIVERABLES

The results of this study will be distributed various agencies, organizations and the public as previously described. Based on the classification information, the Adams County Land and Water Conservation Department will identify assistance requests and determine the appropriate future activities, based on the classification determinations. To provide the requested assistance, Adams County Land and Water Conservation Department will incorporate the lake management plans goals, priorities and action items into its Annual Plan of Operations. Goals, priorities and action items may include educational programs, formation of lake districts, further development of lake management plans and implementation of lake management plans. The lake management plans will also be incorporated into the Adams County Land and Water Conservation Management Plan.

ADAMS COUNTY INFORMATION

Adams County lies in south central Wisconsin, shaped roughly like the outline of Illinois. Adams County is a small rural county with a full-time population of about 20,000. Between 1980 and 2000, Adams County's population grew by more than 20%, with most of the population increase being located upon the lakes and streams. The population increase has resulted in a greater need for facilitation, technical assistance and education, including information on the lakes and streams.

Figure 1: Adams County Location in Wisconsin

WOLF LAKE BACKGROUND INFORMATION

Wolf Lake is a 49-acre natural seepage lake located in the Town of Jackson, Adams County, in the Central Sands Area of Wisconsin. A "seepage lake" is a natural lake with no stream inlet or outlet and fed by precipitation, runoff and groundwater. It is one of many lakes in the Town of Jackson, most of which are seepage lakes similar to Wolf Lake (see arrow below pointing to location in the Town of Jackson).

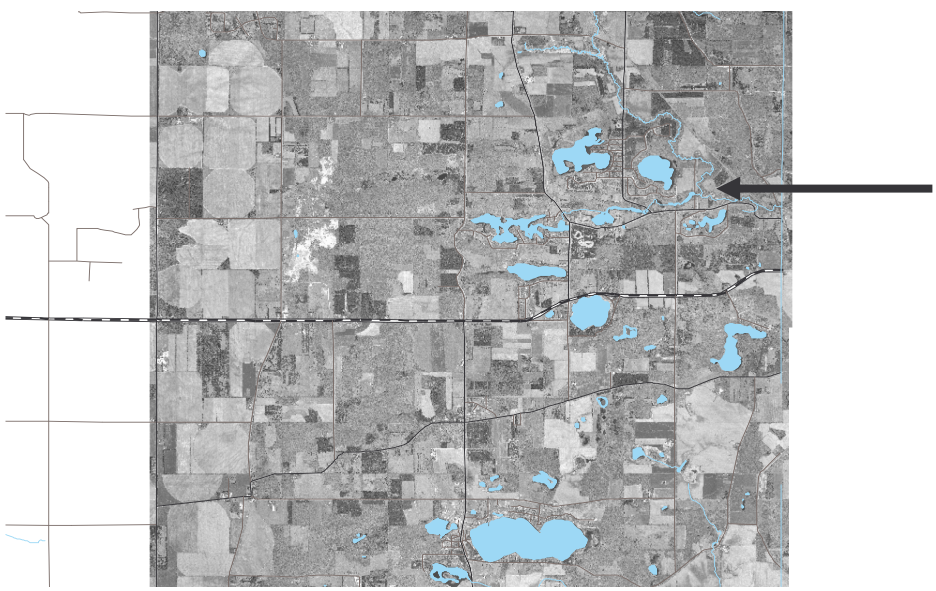


Figure 2: WOLF LAKE location

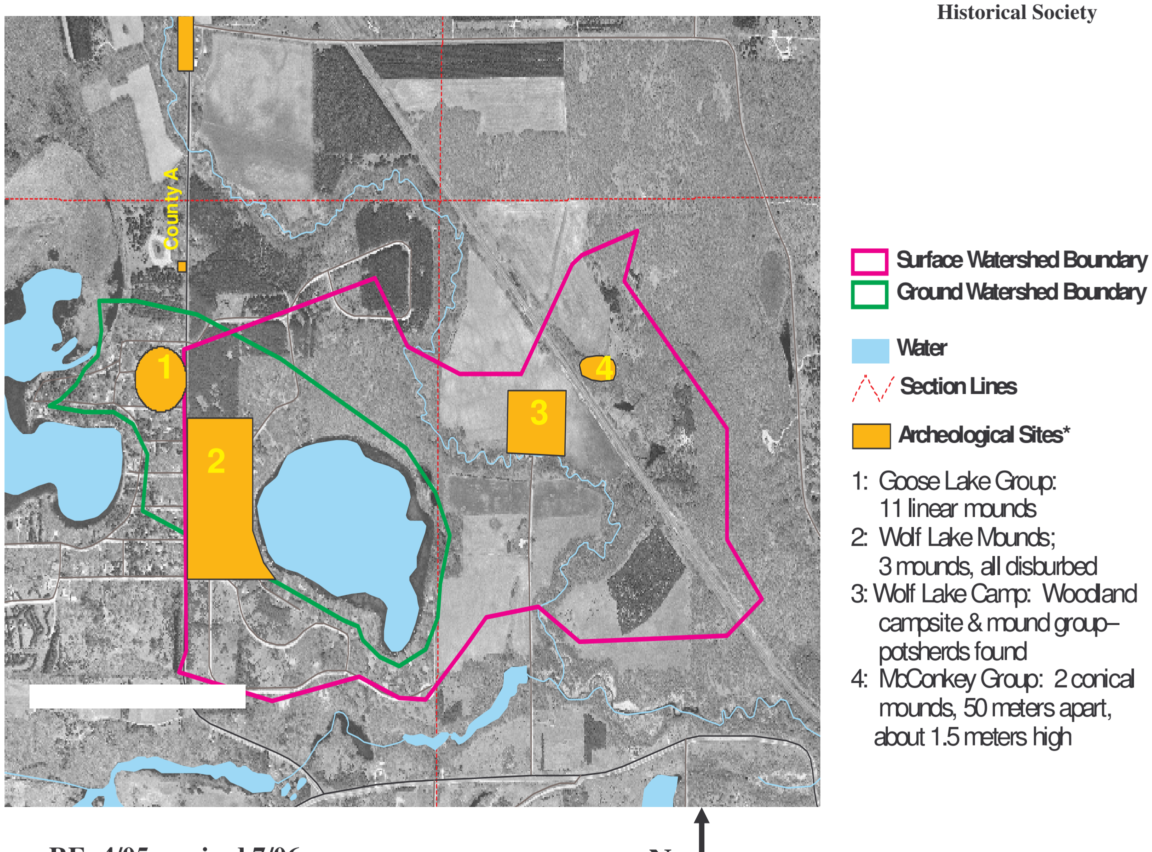
Wolf Lake is part of the Neenah Creek Watershed, a large watershed of 182 square miles from which water flows into the Fox River and eventually into Lake Michigan. The Central Sand Hills, which contain Wolf Lake, are an ecological landscape (a recessional moraine) on the eastern edge of what was Glacial Lake Wisconsin. The area is characterized by glacial moraines and glacial outwash, as well as the kettle holes that formed natural lakes—such as Wolf Lake. Elevations average between 900 to 1000 feet above sea level. Wolf Lake is a no-motor lake for boat traffic.

Archeological Sites

There are many Native American archeological sites in Adams County, with four located right around Wolf Lake. Under the federal act on Native American burials, these sites cannot be further disturbed without permission of the federal government

Figure 3: Wolf Lake Archeological Sites

***info from Wisconsin Historical Society**



RE: 4/05; revised 7/06

Bedrock and Historical Vegetation

Bedrock around Wolf Lake is mostly sandstone, with pockets of dolomite and shale, formed in the Cambrian Period of Geology (542 to 488 millions years ago). Bedrock is generally 50' to 100' down from the land surface. The water table in most areas around Wolf Lake is fairly near the surface.

Original upland vegetation of the area around Wolf Lake included oak-forest, oak savanna, pine barrens and tallgrass prairie. Wetland areas were also common, including wet-mesic prairies, wet prairie, coastal plain marshes and fen. Hills and kettles created by glacial deposits make up the southeast area of Adams County, where Wolf Lake is located.

Soils in the Wolf Lake Watersheds

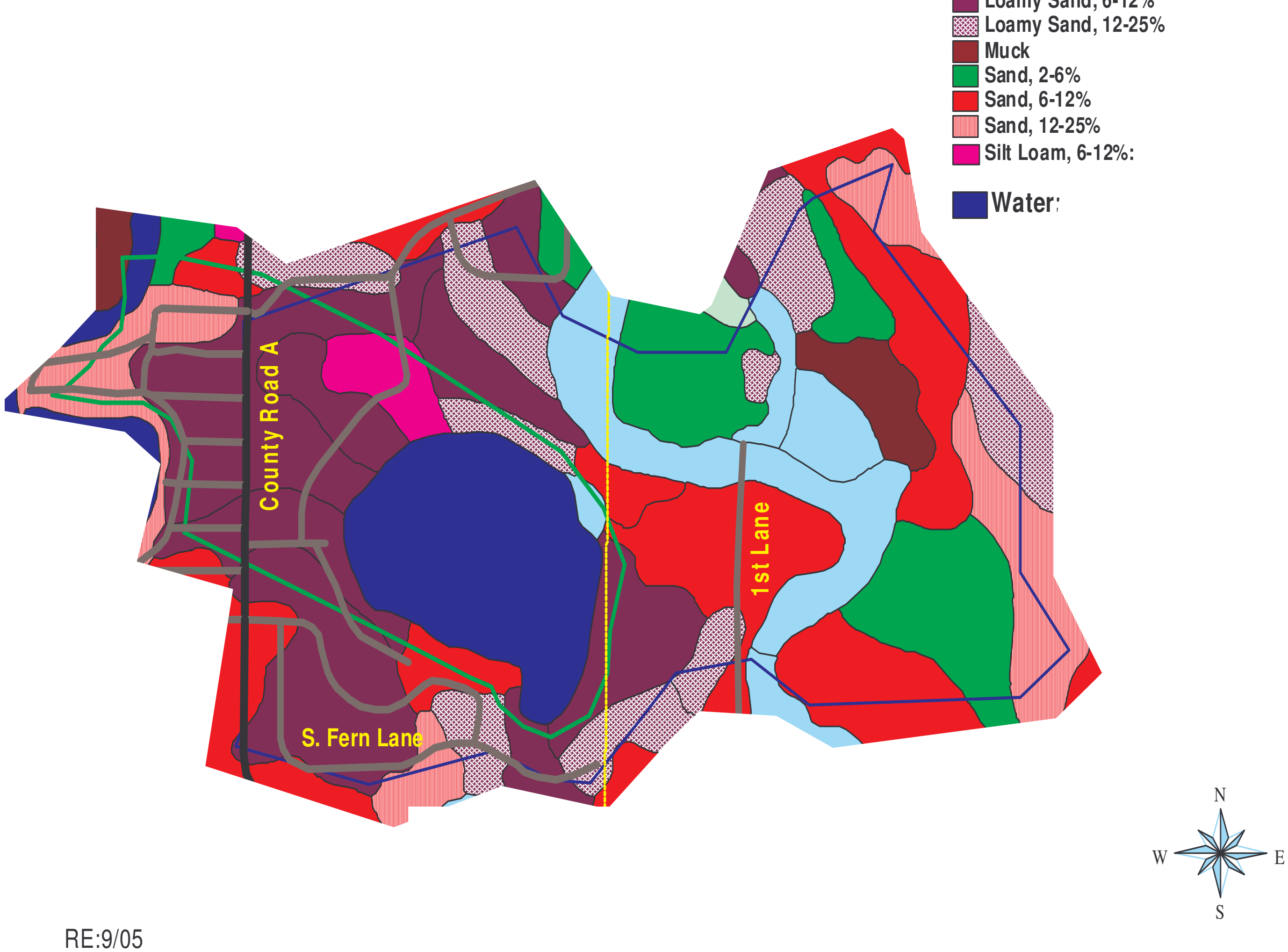
Except for some pockets of muck and silt loam, the soils in the surface and ground watersheds for Wolf Lake are loamy sand and sand, with slopes from very flat up to 25% (see Figure 4). Sandy soils occupy 15.4% of the ground watershed and 35.3% of the surface watershed. 32.83% of the ground watershed is covered with loamy sand, which also covers 44.6% of the surface watershed.

Sandy soil tends to be excessively drained, no matter what the slope. Water, air and nutrients move through sandy soils at a rapid rate, so that little runoff occurs unless the soil becomes saturated. Although water erosion can be a problem, wind erosion may be more of a hazard with sandy soils, especially since they dry out so quickly. There are also draught hazards with sandy soils. Getting vegetation started in sandy soils is often difficult due to the low available water capacity, as well as low natural fertility and organic material. Onsite waste disposal in sandy soils is also a problem because of slope and seepage; mound systems are usually required.

Loamy sands tend to be well-drained, with water, air and nutrients moving through them at a rapid rate. Runoff, when it occurs, tends to be slow. Loamy sands have little water-holding capacity and low natural fertility, although they usually have more organic matter present than do sandy soils. Both wind and water erosion are potential hazards with loamy sands, as is draught. The same difficulties with waste disposal and vegetation establishment are present with loamy sands as with sandy soils.

The soil and soil slopes around lakes and streams are very important to water quality. They affect amount of infiltration of surface precipitation into the ground and the amount of contaminants that may reach the groundwater, as well as the amount of surface stormwater runoff. In addition, these two factors affect the amount and content of pollutants and particles (including soil) that may wash into a water body, affecting its water quality, its aquatic plant community and its fishery. Further, soil types and soil slopes help determine the appropriate private sewage system and other engineering practices for a particular site, since they affect absorption, filtration and infiltration of contamination from engineering practices.

Figure 4: Wolf Lake Watersheds Soils



CURRENT LAND USE

Both the surface and ground watersheds of Wolf Lake are fairly small, as seen in the map and table below. Overall, the two most common current land uses in the Wolf Lake watersheds are woodlands and residences. (See Figures 5, 6a, 6b & 7). In the surface watershed, non-irrigated agriculture is substantial.

Figure 5: Wolf Lake Watersheds Land Use in Acres and Percent of Total

Wolf Lake	Surface Acres	% Total	Ground Acres	% Total	Total Acres	% Total
Agriculture--Non Irrigated	116.23	17.27%	0	0.00%	116.23	14.45%
Residential	189.49	28.17%	99.01	75.24%	288.5	35.87%
Water	51.72	7.69%	0	0.00%	51.72	6.43%
Wetlands	20.36	3.03%	5.96	4.53%	26.32	3.27%
Woodland	294.98	43.84%	26.63	20.23%	321.61	39.98%
total	672.78	100.00%	131.6	100.00%	804.38	100.00%

Studies have shown that land use around a lake has a great impact on the water quality of that lake, especially in the amount and content of surface runoff. (James, T., 1992, I-10; Kibler, D.F., ed. 1982. 271) For example, while natural woodland may (on the average) absorb 3.5" out of a 4" rainfall, leaving only .5" as runoff, a residential area with quarter-acre lots may absorb only 2.3" of the 4", leaving 1.7" to run off the land into the lake—the same amount as may be expected to run off from a corn or soybean field. 1.7" of runoff translates into 46,200 gallons per acre ending up in the lake! Percentage of impervious surface, the soil type, vegetation present and slope of the site can all affect runoff volume.
(Frankenberger, J, ID-230).

Wolf Lake--Surface Watershed Land Use

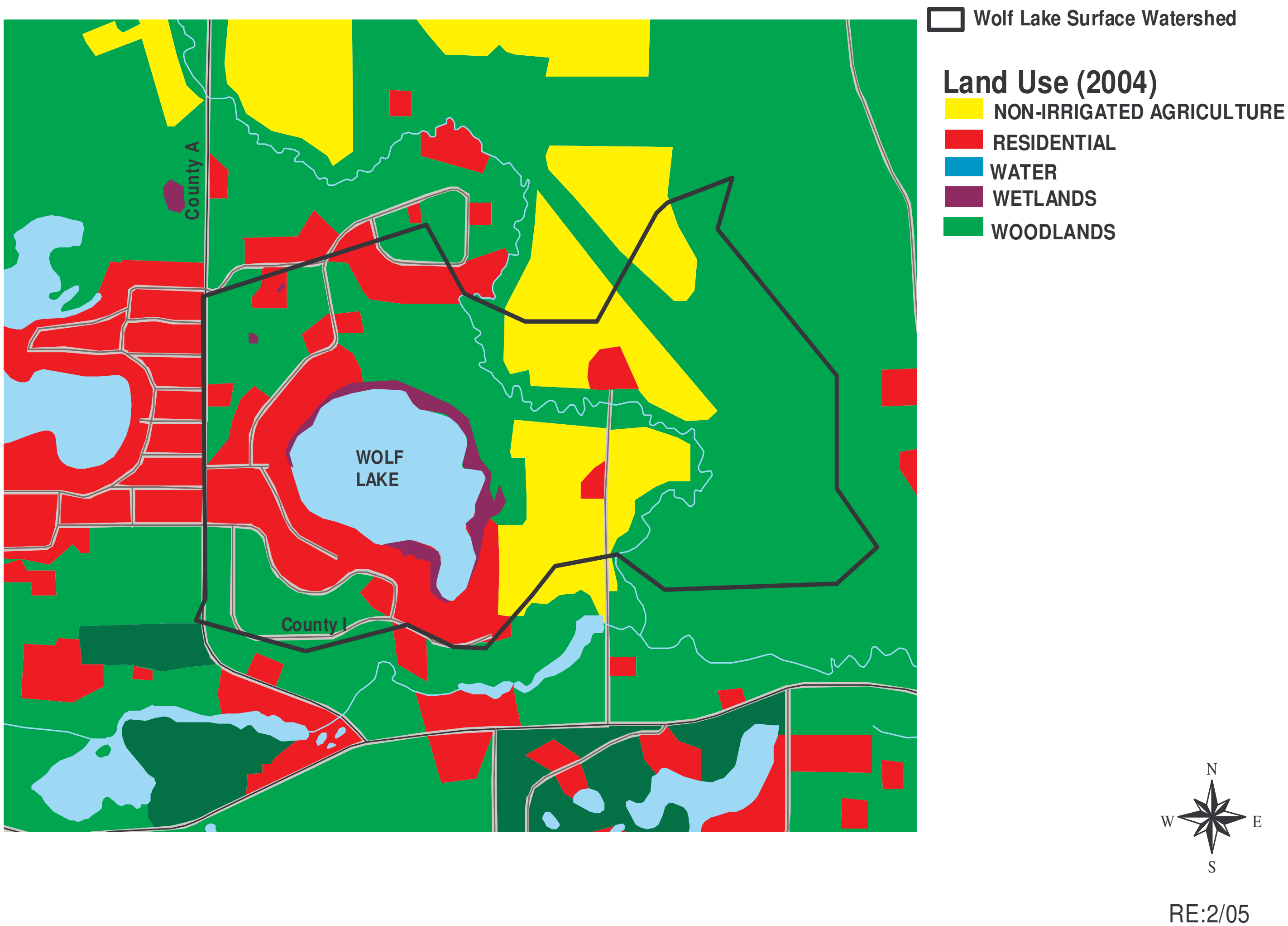
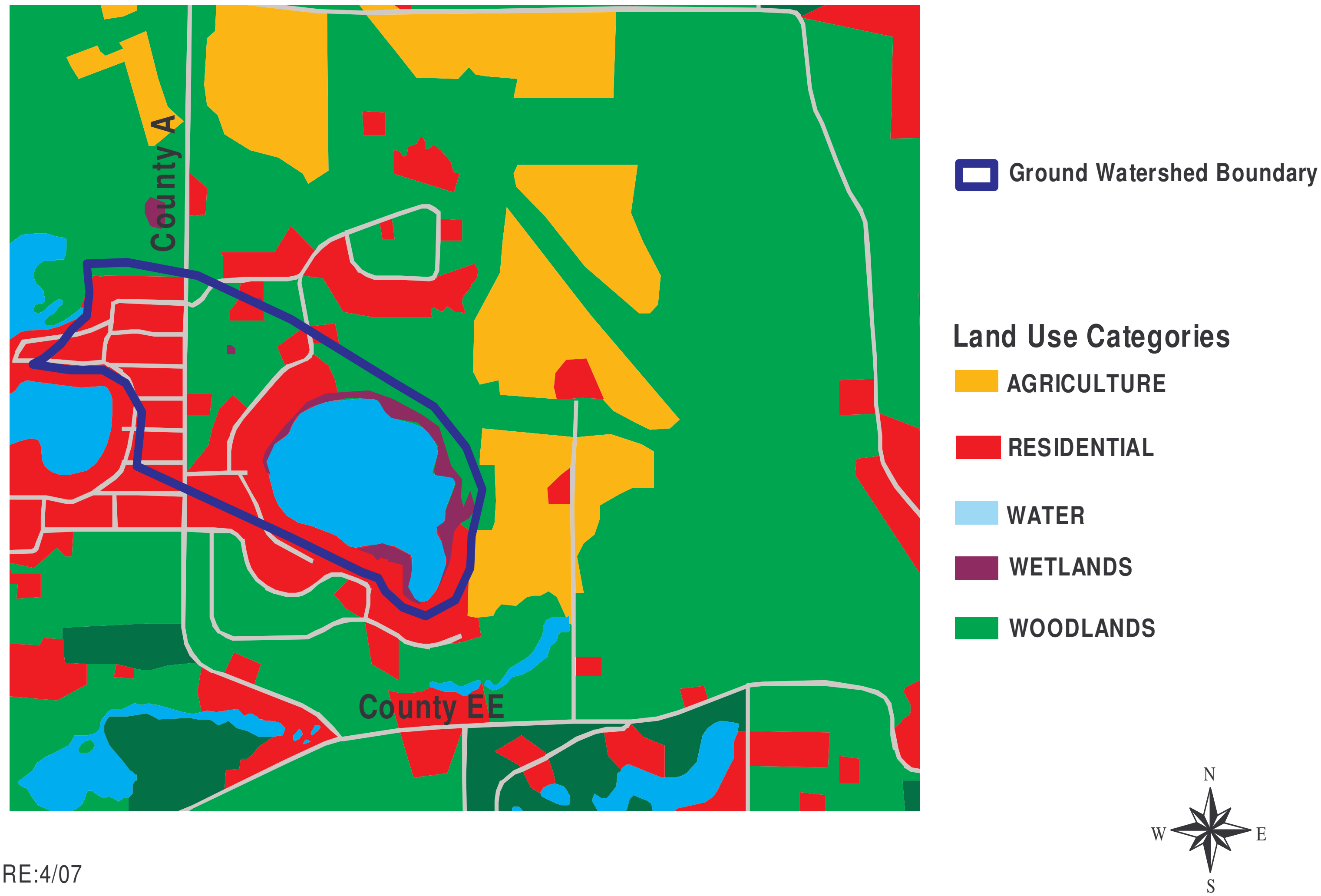


Figure 6a: Land Use in Wolf Lake Surface Watershed

Wolf Lake--Ground Watershed Land Use

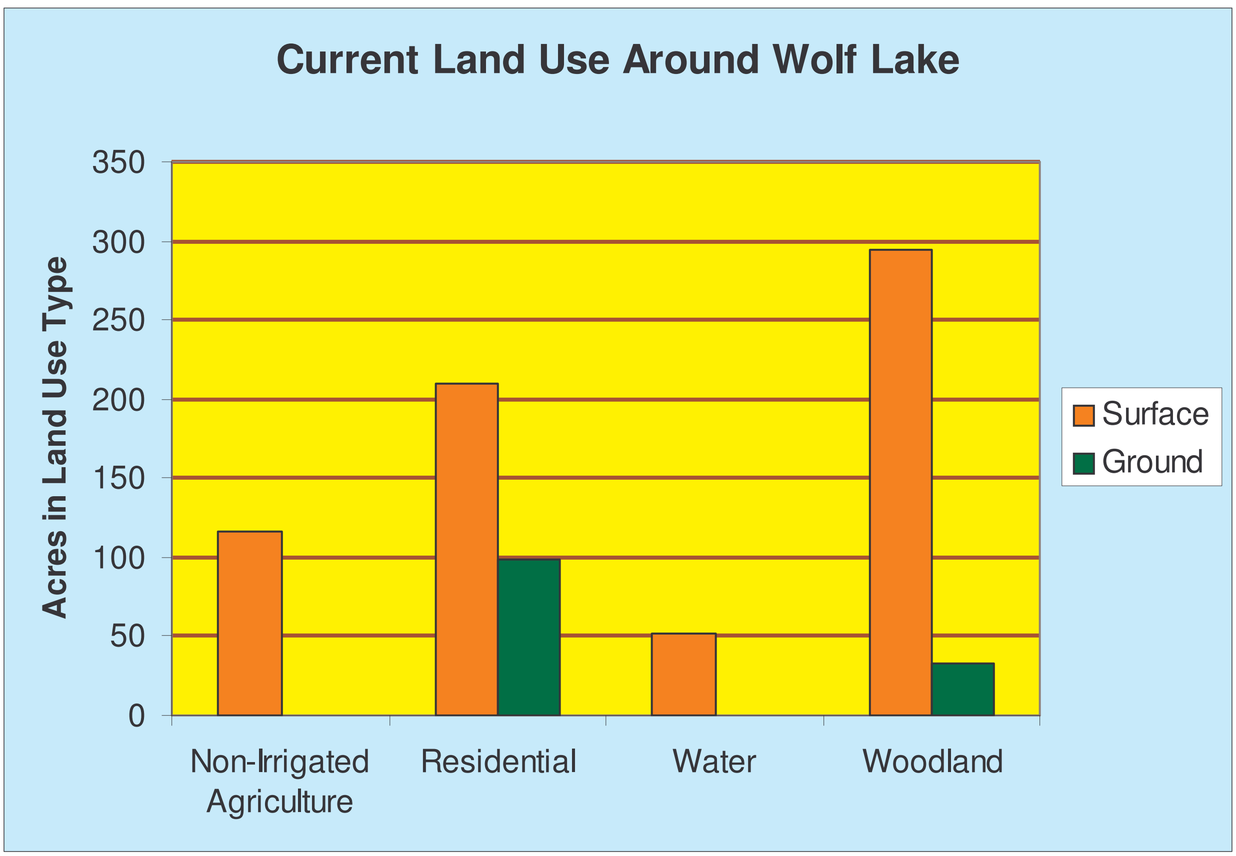


RE:4/07

Figure 6b: Land use in Wolf Lake Ground Watershed

When water runs over a surface, it picks up whatever loose pollutants—sediment, chemicals, metals, exhaust gas, etc—are present on that surface and takes those items with it into the lake. Increased development around a lake tends to increase the amount of pollutants being carried into the lake, thus negatively affecting water quality. Residential development areas with lots of one-quarter acre or less may deliver as much as 2.5 pounds of phosphorus per year to the lake for each acre of development.

Figure 7: Graph of Current Land Use



There are two specific kinds of land use—wetlands and shorelands--that are so important to water quality that they will be separately discussed.

WETLANDS

A number of wetlands are located in the Wolf Lake surface and ground watersheds (Figures 6a & 6b). In the past, wetlands were seen as “wasted land” that only encouraged disease-transmitting insects. Many wetlands were drained and filled in for cropping, pasturing, or even residential development. In the last few decades, however, the importance of wetlands has become evident, even as wetlands continue to decline in acreage.

Wetlands play an important role in maintaining water quality by trapping many pollutants in runoff and flood waters, thus often helping keep clean the water they connect to. They serve as buffers to catch and control what would otherwise be uncontrolled water and pollutants. Wetlands also play an essential role in the aquatic food chain (thus affecting fishery and water recreation), as well as serving as spaces for wildlife habitat, wildlife reproduction and nesting, and wildlife food.

Figure 8: Wolf Lake shore wetland

The photo above (Figure 8) shows one of the wetlands along the shore of Wolf Lake. Looking at the map of wetlands directly around Wolf Lake (see Figure 9) makes it evident how important wetlands are to Wolf Lake…more than 1/3 of the lake has wetlands at or near the shore that serve as filters and trappers that help keep the lake as clean as it is. It is essential to preserve these wetlands for the health of Wolf Lake.

Figure 9: Wetlands Directly Around Wolf Lake

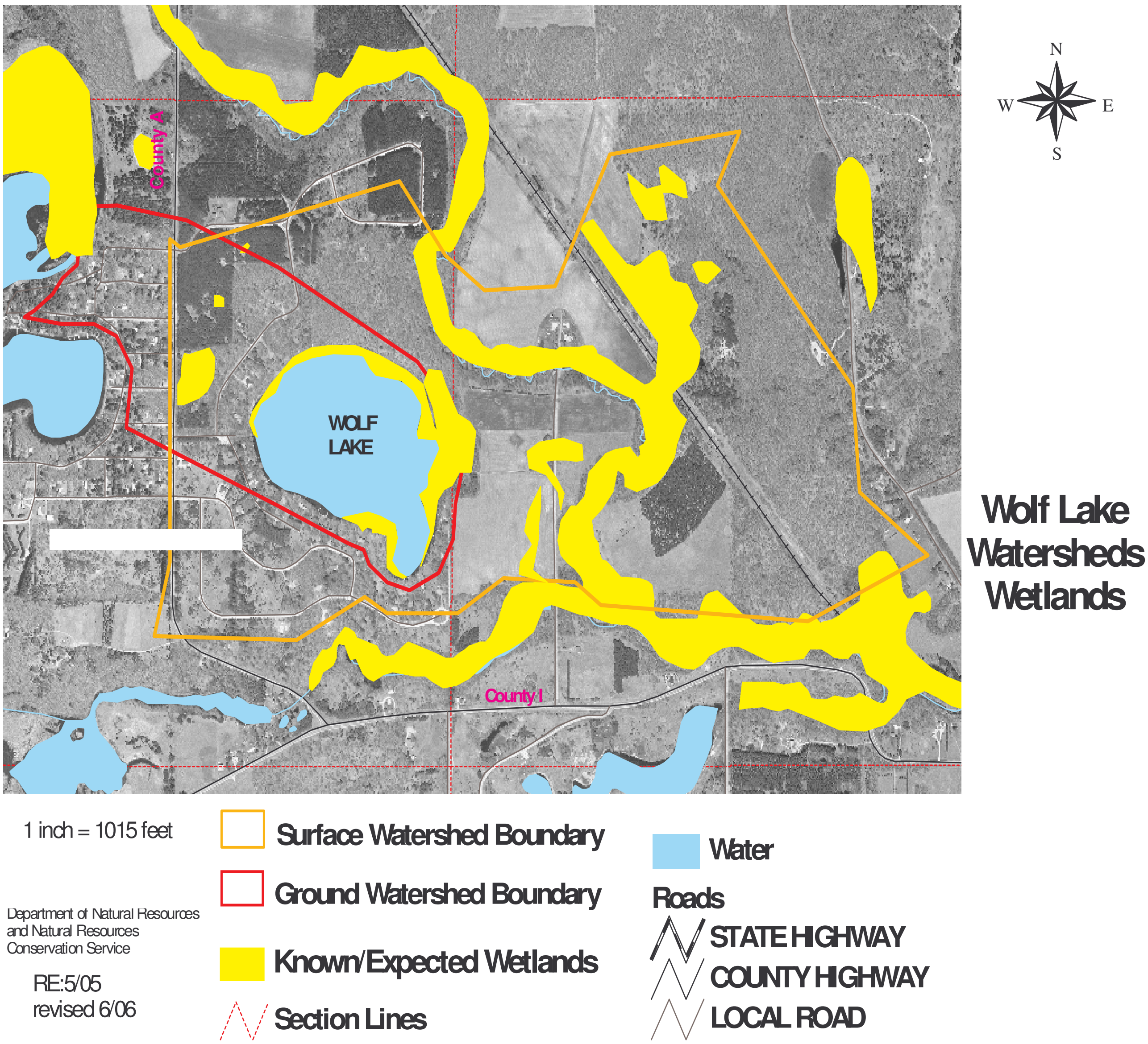


Figure 10: Another Wolf Lake Shore Wetland

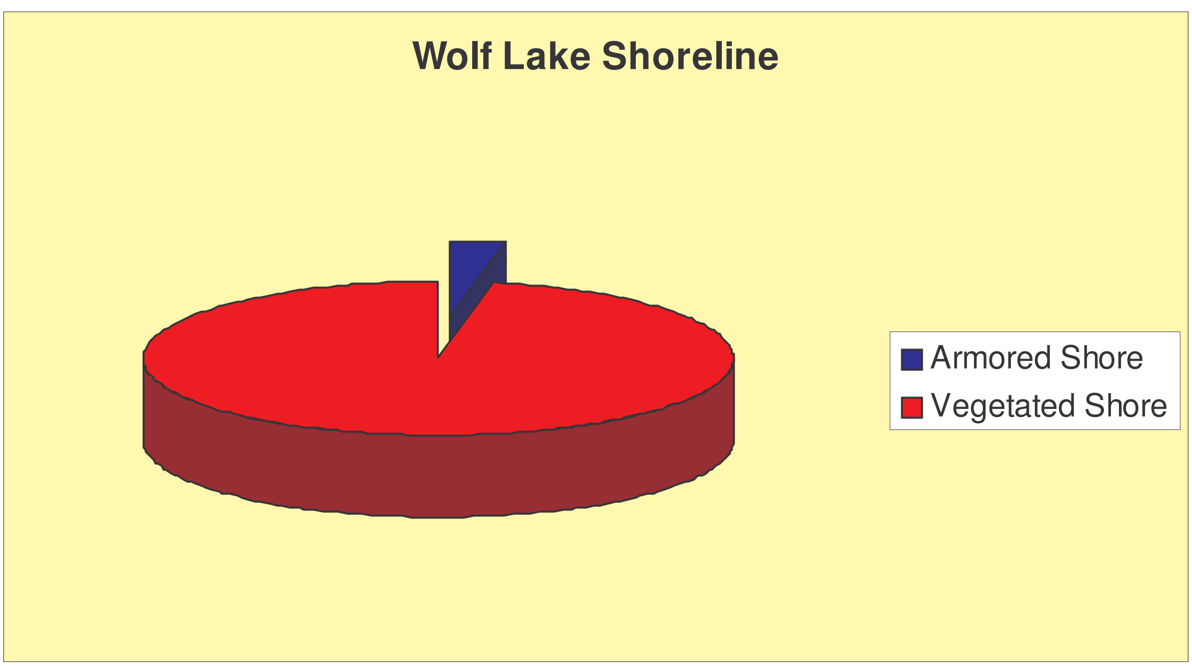
SHORELANDS

Wolf Lake has a total shoreline of 1.4 miles (7392 feet). About 1/3 of the northern shore is owned by the Wisconsin Department of Natural Resources and has been left unaltered. Included in that area are a bog and a sedge meadow. Areas immediately at the shore are steeply sloped.

The balance of the shore consists of privately-owned lots and a boat ramp area owned by the Town of Jackson. Two different developers developed that part of Wolf Lake's shoreline. Both included covenants that required buildings to be erected using native materials, mostly wood. Most of the areas near the shore are steeply sloped, except at the far northeast end, where the land is flatter. Buildings are generally located 70 or more feet back from the shore.

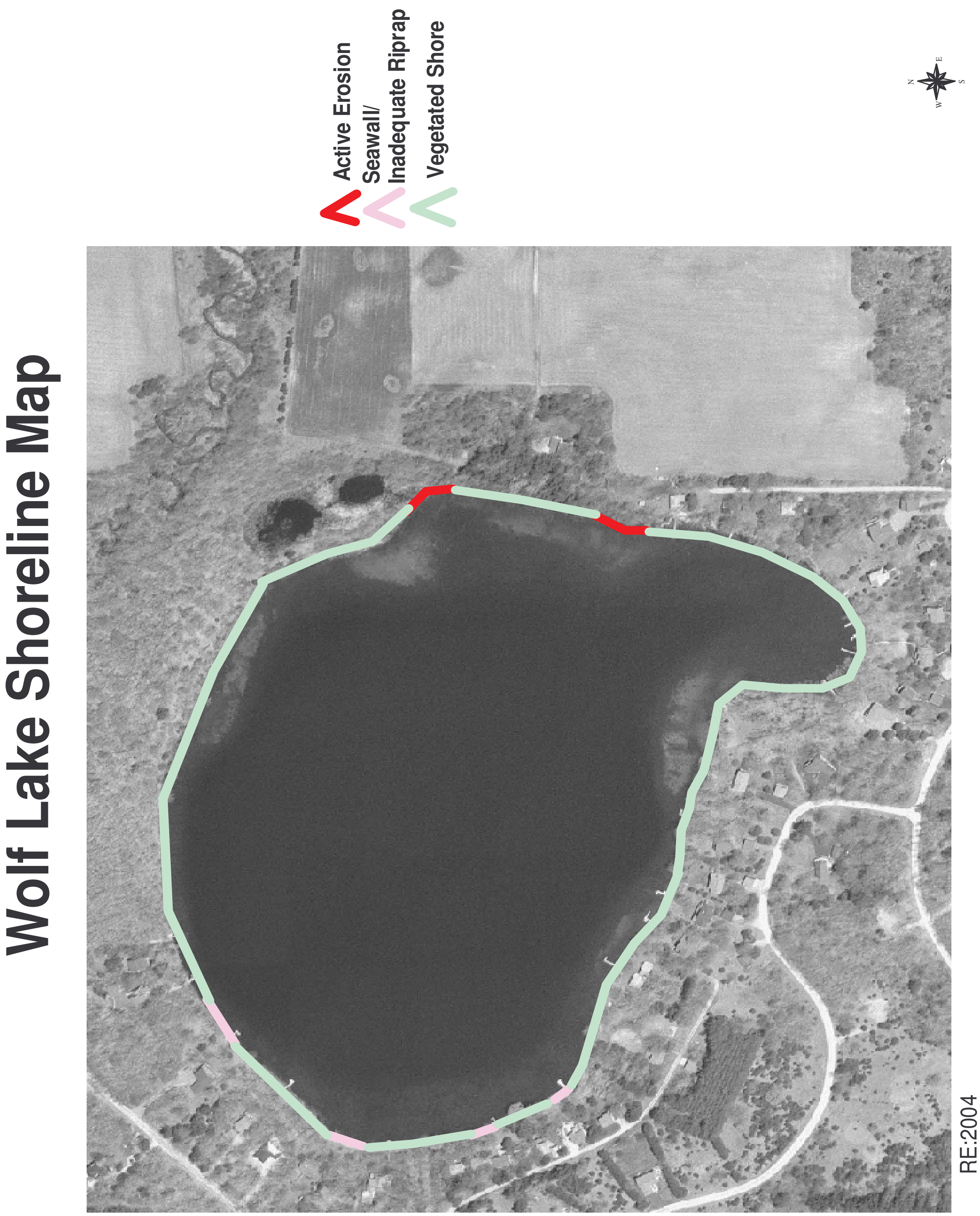
The Adams County Land & Water Conservation Department conducted a survey of the Wolf Lake shoreline in 2004. Shore types were categorized as "armored" and "vegetated". "Armored" shores included seawalls of any material and rock riprap and are only about 219 feet of Wolf Lake's shore. "Vegetated" shores encompassed both native vegetation of any type and traditional mowed lawns and covered 7173 feet of shore (see Figure 11).

Figure 11: Wolf Lake Shores Status



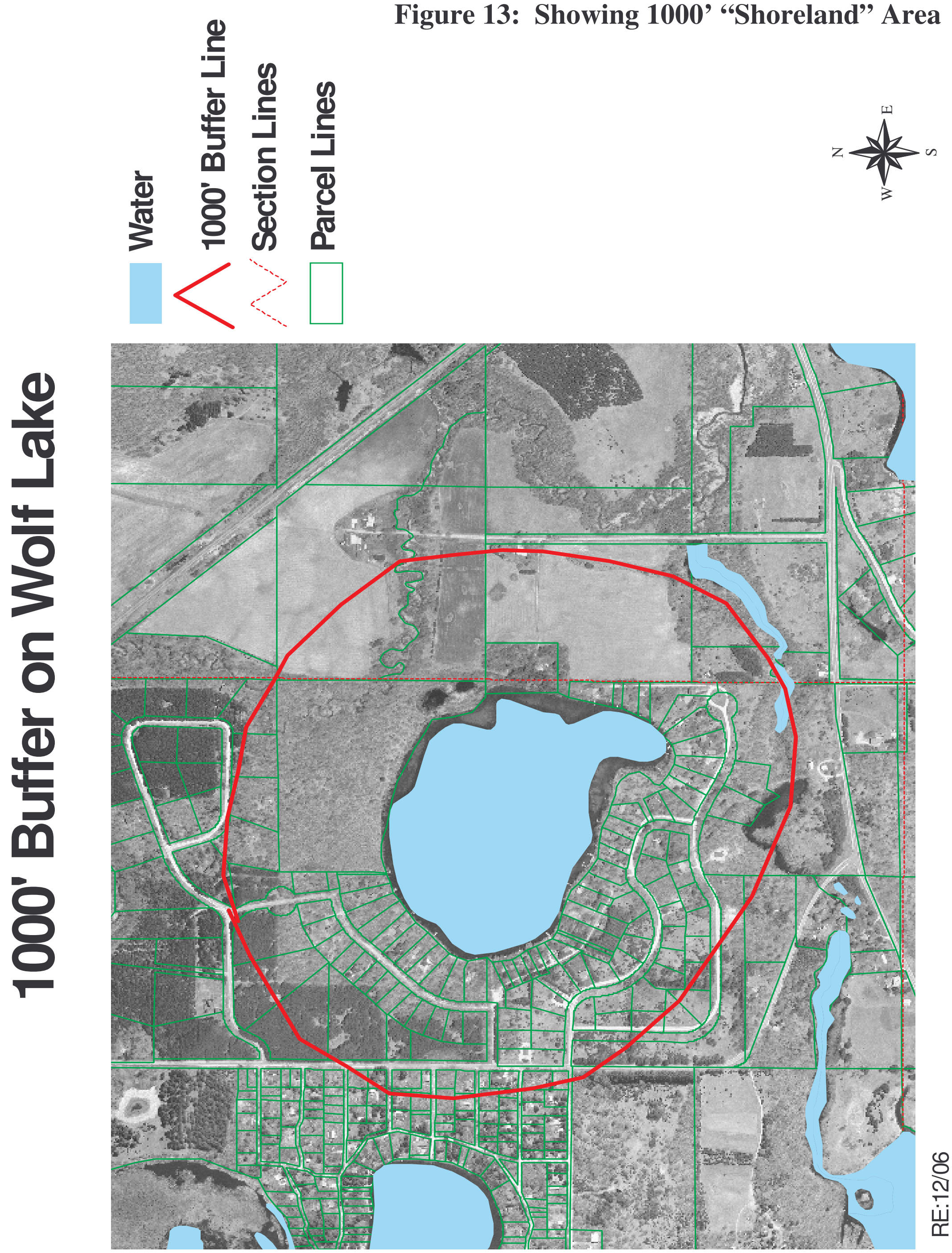
Locations of the shores are shown on the map (Figure 12):

Figure 12: Wolf Lake Shoreline Map



The Adams County Shoreline Ordinance defines 1000’ landward from the ordinary high water mark as “shoreland”. Figure 13 shows this area of Wolf Lake.

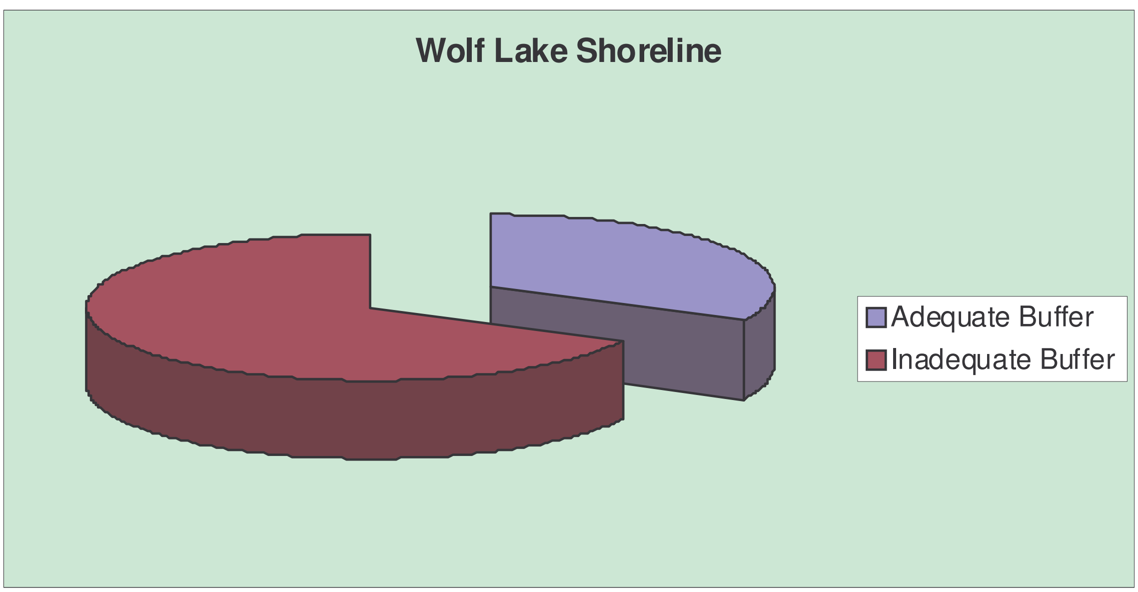
Figure 13: Showing 1000’ “Shoreland” Area



Under the ordinance, the first 35 feet landward from the water is a "buffer." Shoreland buffers are an important part of lake protection and restoration. These buffers are simply a wide border of native plants, grasses, shrubs and trees that filter and trap soil & similar sediments, fertilizer, grass clippings, stormwater runoff and other potential pollutants, keeping them out of the lake. A 1990 study of Wisconsin shorelines revealed that a buffer of native vegetation traps 5 to 18 times more volume of potential pollutants than does a developed, traditional lawn or hard-armored shore.

The 2004 inventory included classifying areas of the Wolf Lake shorelines as having "adequate" or "inadequate" buffers (see Figure 14). An "adequate" buffer was defined as one having the first 35 feet landward covered by native vegetation. An "inadequate" buffer was anything that didn't meet the definition of "adequate buffer", including native vegetation strips less than 35 feet landward. Using these definitions, 32.6% (about 2510 feet) of Wolf Lake's shoreline had an "adequate buffer", leaving 67.4% (4882 feet) as "inadequate." Most of the "inadequate" buffer areas were found with traditional mowed lawns and/or insufficient native vegetation at the shoreline to cover 35 feet landward from the water line.

Figure 14: Buffer Categories on Wolf Lake



Vegetated shoreland buffers help stabilize shoreline banks, thus reducing bank erosion. The plant roots give structure to the bank and also increase water infiltration and decrease runoff. A vegetated shore is especially important when shores are steep and soft, as are many of the Wolf Lake shores. Figure 15 maps the adequate and inadequate buffers on Wolf Lake.

Wolf Lake Buffer Map

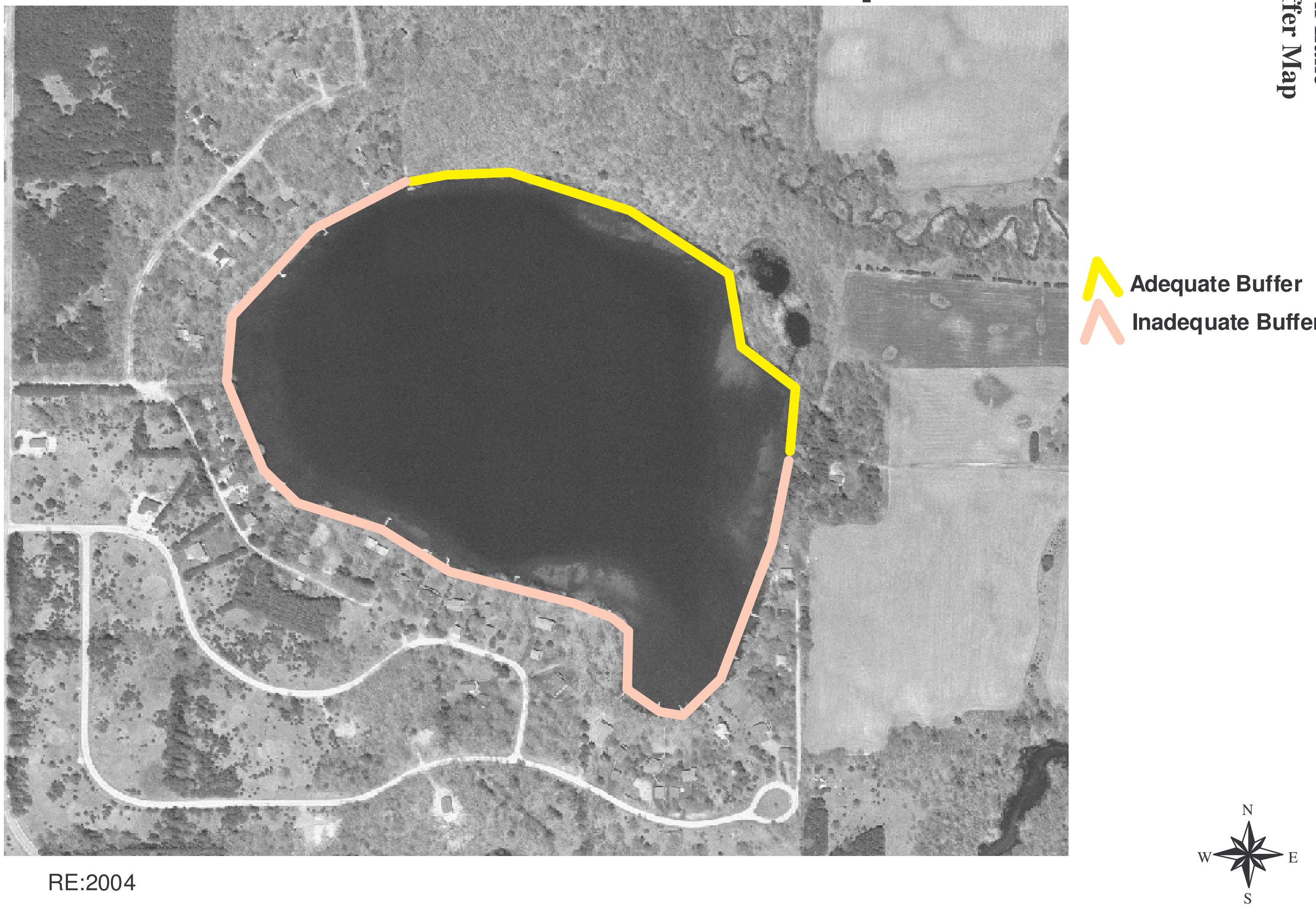


Figure 15: Wolf Lake Buffer Map

Lakeside buffers also serve as important habitat. Lake edges usually contain aquatic and wetland plants, grading into drier groundcover, then shrubs and trees as one moves inland towards drier land. Buffers provide habitat for many species of water-dependent wildlife, including furbearers, reptiles, birds and insects. Many wildlife species, including birds, small mammals, fish & turtles breed, nest, forage and/or perch in shore buffer areas. Further, 80% of the endangered and threatened species listed spend part of their life in this near-lake buffer area. (Wagner et al, 2006)

When the natural shoreline is replaced by traditional mowed turf-grass lawns, rock, wooden walls or similar installments, bird and animal life, land-based insects, and aquatic insects that hatch or winter on natural shore are negatively impacted. For example, on many Adams County lakes, the non-native aquatic plant, Eurasian Watermilfoil has invaded. There is a weevil native to Wisconsin that weakens Eurasian Watermilfoil by burrowing into and developing within its stems, but that weevil depends on a native-plant shore to overwinter. If the shore is instead covered by rock, seawall or traditional lawn, these weevils will be unavailable for the lake to use as Eurasian Watermilfoil control.

Figure 16: Inadequate Vegetative Buffer on Wolf Lake

The filtering process and bank stabilization that buffers provide help improve a lake's water quality, including water clarity. Studies in Minnesota, Maine and Michigan have shown that waterfront property value increases for every foot the water clarity of a lake increases. (Krysel et al, 2003).

Figure 17: Adequate Buffer on Wolf Lake

Natural shoreland buffers serve important cultural functions. They enhance the lake's aesethics. Studies have shown that aeshetics rank high as one of the reasons people visit or live on lakes. Shore buffers can provide visual & audio privacy screens for homeowners from other neighbors and/or lake users.

Adequate buffers on Wolf Lake could be easily installed on most of the lake by either letting the first 35 feet landward from the water just grow without mowing it, except for a path to the water, or—if something more controlled or aesthetically pleasing was desired—by planting native seedlings sufficient to fill in the first 35 feet.

WATER QUALITY

Between 2004 and 2006, Adams County Land & Water Conservation Department gathered water chemistry and other water quality information on 20 lakes in Adams County with public access. Wolf Lake was one of these lakes. Part of the information was gained from periodic water sampling done by Adams County LWCD. Historic information about water testing on Wolf Lake was also obtained from the Wisconsin Self-Help Monitoring Program records (1990-2004) and from the WDNR (1992-2004).

Phosphorus

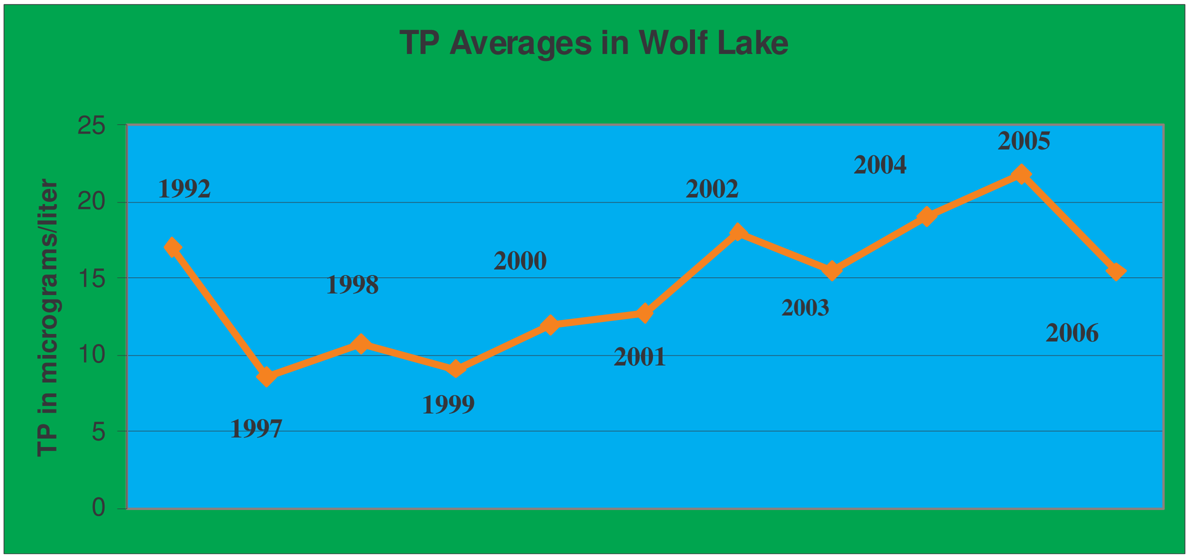
Most lakes in Wisconsin, including Wolf Lake, are phosphorus-limited lakes: of the pollutants that end up in the lake, the one that most affects the overall quality of the lake water is phosphorus. The amount of phosphorus especially affects the frequency and density of aquatic vegetation and the frequency and density of various kinds of algae, as well as water clarity and other quality aspects. One pound of phosphorus can produce as much as 500 pounds of algae.

Phosphorus is not an element that occurs in high concentration naturally, so any lake that has significant phosphorus readings must have gotten that phosphorus from outside the lake or from internal loading. Some phosphorus is deposited onto the lake from atmospheric deposition, especially from soil or other particles in the air carrying phosphorus. A lake that includes a flooded wetland area may have a significant amount of phosphorus being released during the flushing of the wetland area. Phosphorus may accumulate in sediments from dying animals, dying aquatic plants and dying algae. If the bottom of the lake becomes anoxic (oxygen-depleted), chemical reactions may cause phosphorus to be released to the water column.

Although there are several forms of phosphorus in water, the total phosphorus (TP) concentration is considered a good indicator of a lake's nutrient status, since the TP concentration tends to be more stable than other types of phosphorus concentration. For a natural lake like Wolf Lake, a total phosphorus concentration below 20 micrograms/liter tends to prevent nuisance algal blooms. Wolf Lake's growing season (June-September) surface average total phosphorus level of 17.3 micrograms/liter is low enough so that nuisance algal blooms should occur only rarely.

The limiting factor in most Wisconsin lakes, including Wolf Lake, is phosphorus. Measuring the phosphorus in a lake system thus provides an indication of the nutrient level in a lake. Increased phosphorus in a lake will feed algal blooms and also may cause excess plant growth. The 2004-2006 summer average phosphorus concentration in Wolf Lake was 17.3 ug/liter. This is below the 25 ug/l average for natural lakes in Wisconsin. This concentration suggests that Wolf Lake is likely to have few nuisance algal blooms. This places Wolf Lake in the "good" water quality section for impoundments, and in the "mesotrophic" level for phosphorus.

Figure 18: Summer Epilimnetic Total Phosphorus Averages in Wolf Lake

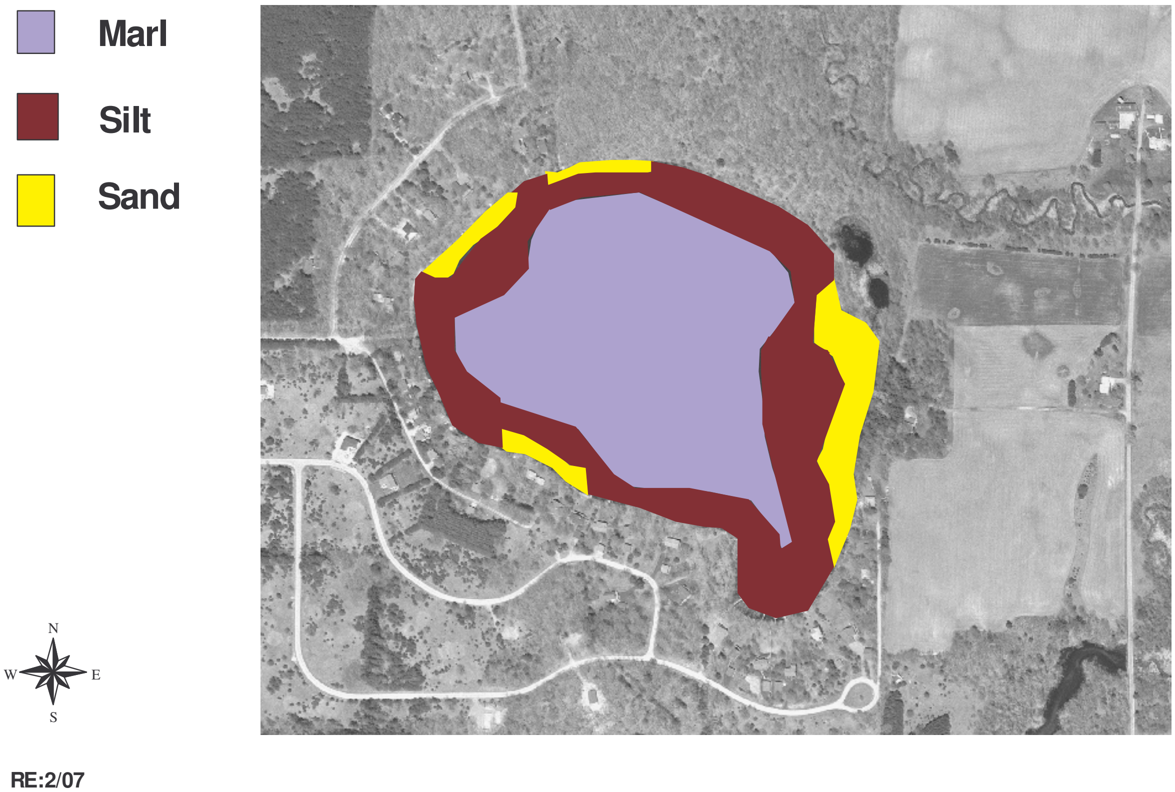


However, a comparison of the average summer phosphorus level in the lower depths of Wolf Lake (40' and deeper) to the upper depths (surface to 5') shows that phosphorus concentrations in the lower levels of Wolf Lake are 1.5 times more in June-July and 3.5 times higher in Aug-Sept than those from the upper layers of water. This suggests that the lower water depths may be accumulating phosphorus, added to that accumulating in the sediments. This situation should be monitored

As the above graph (Figure 18) indicates, the growing season total phosphorus levels have varied, but stayed (except for 2005) below the 20 micrograms/milliliter recommended to avoid nuisance algal blooms. Still, considering that the overall line since 1997 has been showing mostly increased total phosphorus levels for the growing season, phosphorus should continue to be monitored.

In most lakes in Wisconsin, phosphorus concentration in the bottom sediments of the lake is considerably higher than the concentration in the water column itself. Bottom sediments can "bind up" phosphorus, making it unavailable for aquatic plants or algae to use. Some sediment types hold phosphorus at a higher rate than others.

Figure 19: Sediment Map of Wolf Lake



As can be seen on the sediment map (Figure 19), much of the bottom of Wolf Lake is marl sediment. "Marl" is a calcium carbonate precipitate (solid) that forms in hardwater lakes when both calcium and pH levels are high. Marl can be good for a lake because it has a high capacity to bind phosphorus, as well as other nutrients. With such a large amount of marl sediment, Wolf Lake may benefit from it removing phosphorus from water column, thus making it unavailable for algal and aquatic plant growth.

How much a marl sediment affects aquatic plant and algal growth will depend on where the marl sediment is located, i.e., if the aquatic plants are rooted in the marl, so that they can still draw phosphorus from it, the presence of marl may not reduce aquatic plant growth. Effect will also depend on how much phosphorus the marl has already absorbed. In 80% of Wisconsin's lakes, phosphorus is the key nutrient that determines the amount of algae and aquatic plant growth. Since much of the marl in Wolf Lake is in the deeper areas of the lake, the marl sediment probably offers more protection against nuisance algal growth than aquatic plant growth.

Groundwater testing of various wells around Wolf Lake was done by Adams County LWCD and included a test one year for total phosphorus levels in the groundwater coming into the lake. The average TP level in the wells tested was 21.7 micrograms/liter, somewhat higher than the lake surface water results. This phosphorus may also seep into Wolf Lake.

Land use plays a major role in phosphorus loading. A key component of the computer models used is the phosphorus budget, that is, the estimated amount of phosphorus delivered to the lake from each land use type annually. The land uses that contribute the most phosphorus are non-irrigated agriculture and residences. Using the current land use data, as well as phosphorus readings from 2004 through 2006 water sampling, a phosphorus loading prediction model was run for Wolf Lake. The current results are shown in the table below:

Figure 20: Current Phosphorus Loading by Land Use

PHOSPHORUS LOADING	**Loading**	**% of total**
Land Use Type	**lb/yr**	**P loading**
Non-Point Sources		
Non-Irrigated Agriculture	41.80	32.7%
Residential	44.00	35.6%
Forest	13.20	10.4%
Groundwatershed	6.60	4.6%
Lake Surface	6.60	5.2%
septics	14.52	11.50%
total in pounds/year	126.72	100.0%

Phosphorus deposits such as that from flooded wetlands or from atmospheric deposition cannot be controlled by humans. However, some phosphorus (and other nutrient) input can be decreased or increased by changes in human land use patterns. Practices such as shoreland buffer restoration; infiltrating stormwater runoff from roof tops, driveways and other impervious surfaces; using no phosphorus lawn fertilizers; and reducing phosphorus input to and properly managing septic systems will minimize phosphorus inputs into the lake. Circumstances such as increased impervious surface, lawns mowed to water's edge, disturbance of shore areas, improperly-functioning septic systems and removal of native vegetation can greatly increase the volume and content of runoff—and thus increase the volume of phosphorus entering the lake. Many of these practices can also increase the concentration of phosphorus entering the lake, by runoff or other methods of entry.

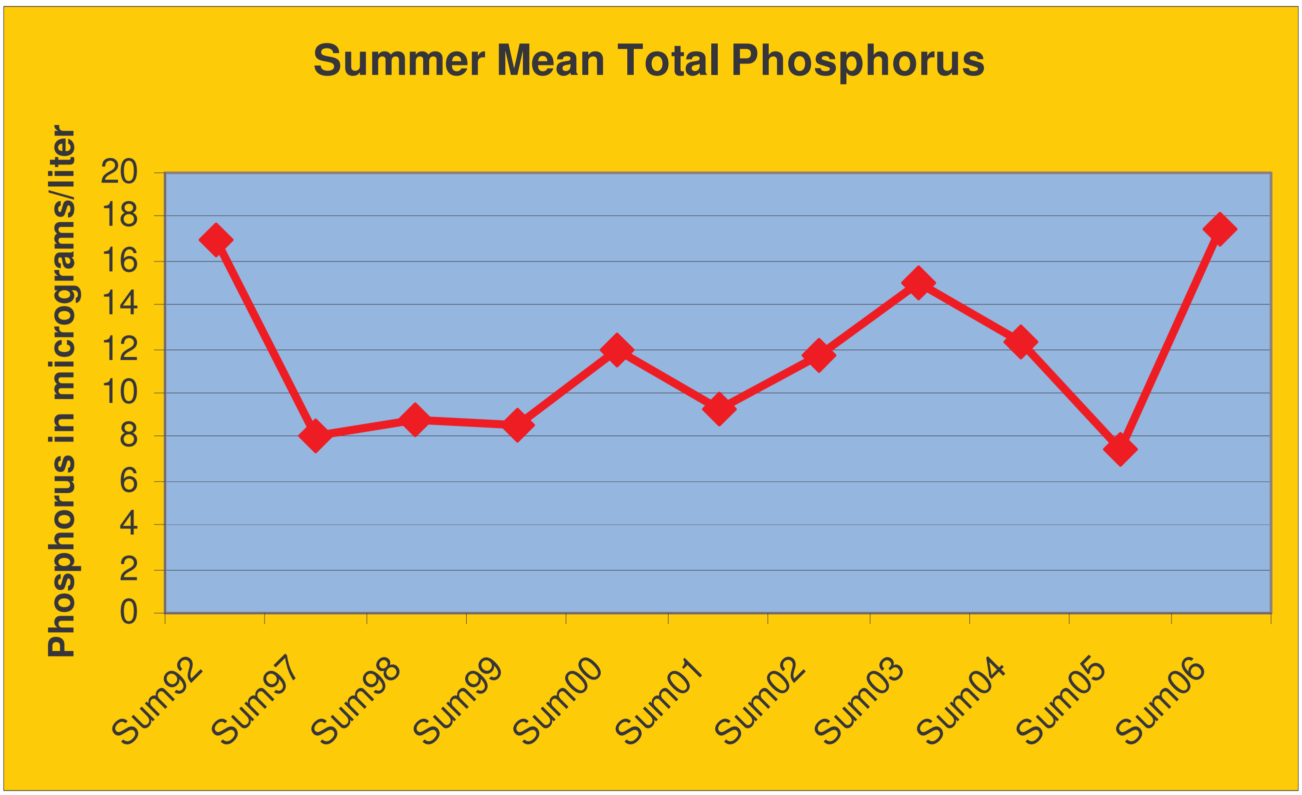
The models were run using not only the current known phosphorus readings in the lake, but also representing decreases or increases of human-controlled phosphorus input by 10%, 25%, and 50%. Results are shown in Figure 21. The figures may not seem like much---until you calculate that one pound of phosphorus can result in up to 500 pounds of algae. A 10% reduction in these three areas could result in 5345 pounds less of algae per year!

Figure 21: Impact of Changes in Overall Phosphorus Input

PHOSPHORUS LOADING	**Loading**			
Land Use Type	**lb/yr**			
Non-Point Sources		-10%	-25%	-50%
Non-Irrigated Agriculture	41.80	37.62	31.35	20.90
Residential	44.00	39.60	33.00	22.00
Forest	13.20	13.20	13.20	13.20
Groundwatershed	6.60	5.94	4.95	3.30
Lake Surface	6.60	6.60	6.60	6.60
septics	14.52	13.07	10.89	7.26
total in pounds/year	126.72	116.03	99.99	73.26

Looking at this issue in terms of how much phosphorus readings in the lake might change, based on the computer modeling, in-lake perhaps makes it clearer. Figure 20 shows that current surface summer (June-September) mean phosphorus levels for Wolf Lake since 1992. The overall average for those 14 years was 11.59 micrograms/liter.

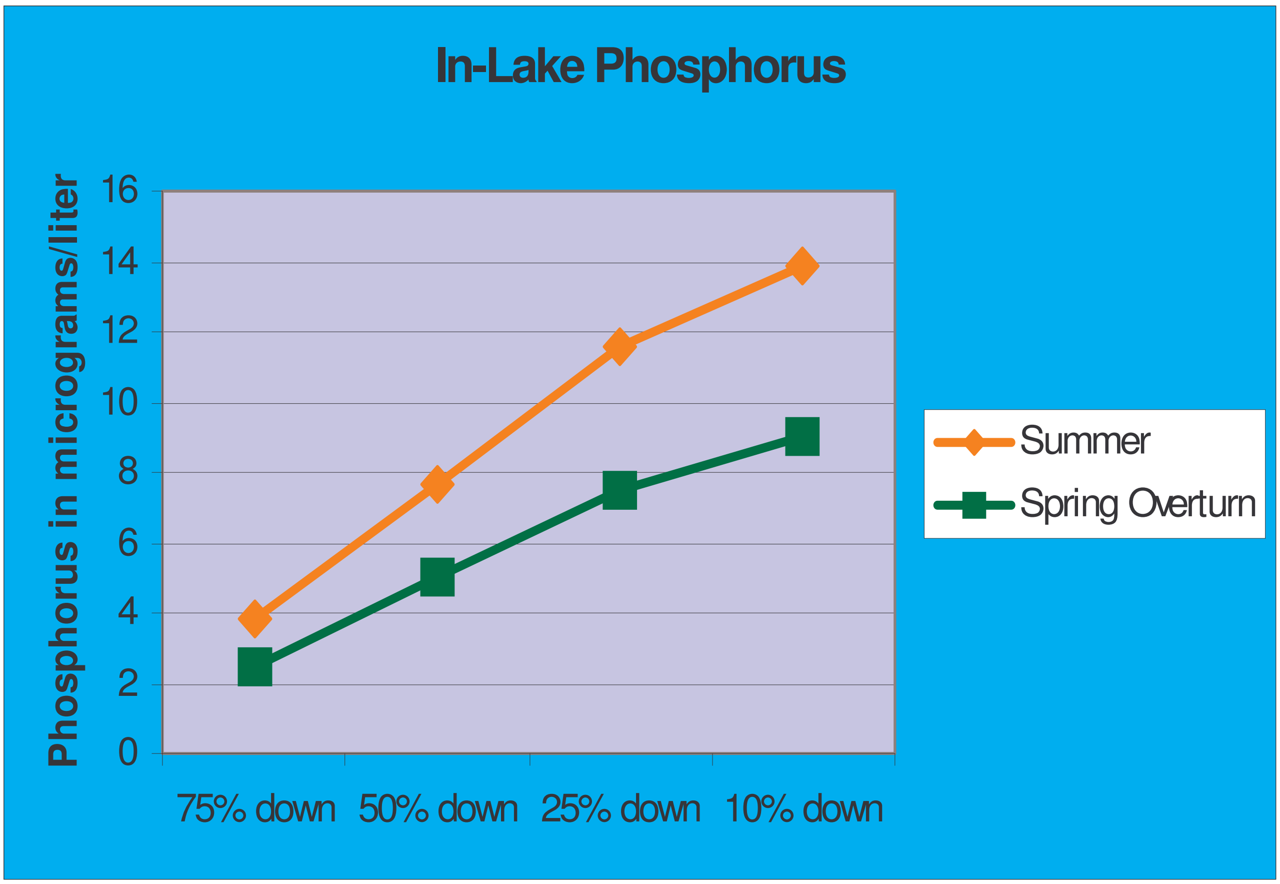
Figure 22: Average Summer Mean Total Phosphorus 1992-2006



Reducing the amount of input from the surface and ground watersheds results in less nutrient loading into the lake itself. Under the modeling predictions, reducing phosphorus inputs from human-based activities even 10% could improve Wolf Lake water quality by up to 2 micrograms of phosphorus/liter; a 25% reduction could save up to 4 micrograms/liter (see Figure 21). Currently, both the spring turnover and summer phosphorus levels are below the threshold value of 20 micrograms/liter, but a phosphorus increase from human activities of only 25% would put the phosphorus levels in the lake over that threshold in the summer. The result would be more algal blooms and more aquatic plants. Decreases would reduce those problems (see Figure 22).

These predictions make it clear that reducing current phosphorus inputs to the lake are essential to improve, maintain and protect Wolf Lake's health for future generations.

Figure 23: Impact on In-Lake Phosphorus Levels by Human-Impacted Phosphorus Inputs



Water Clarity

Water clarity is a critical factor for plants. If plants don't get more than 2% of the surface illumination, they won't survive. Water clarity can be reduced by turbidity (suspended materials such as algae and silt) and dissolved organic chemicals that color or cloud the water. Water clarity is measured with a Secchi disk. **Average summer Secchi disk clarity in Wolf Lake in 2004-2006 was 13.63 feet.** This is very good water clarity, putting Wolf Lake into the "oligotrophic" category for water clarity.

Records since 1990 show that the water clarity in Wolf Lake has consistently remained high (see Figure 24).

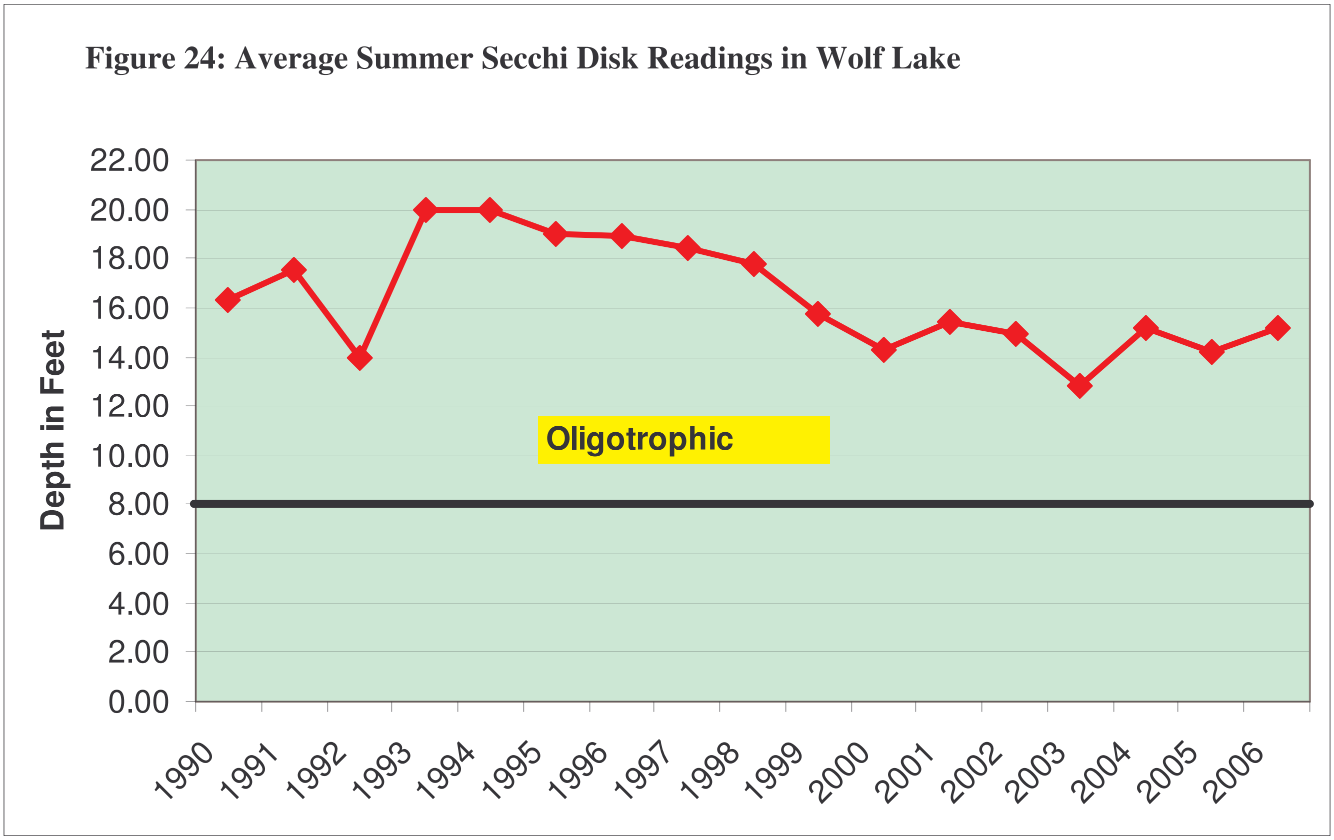


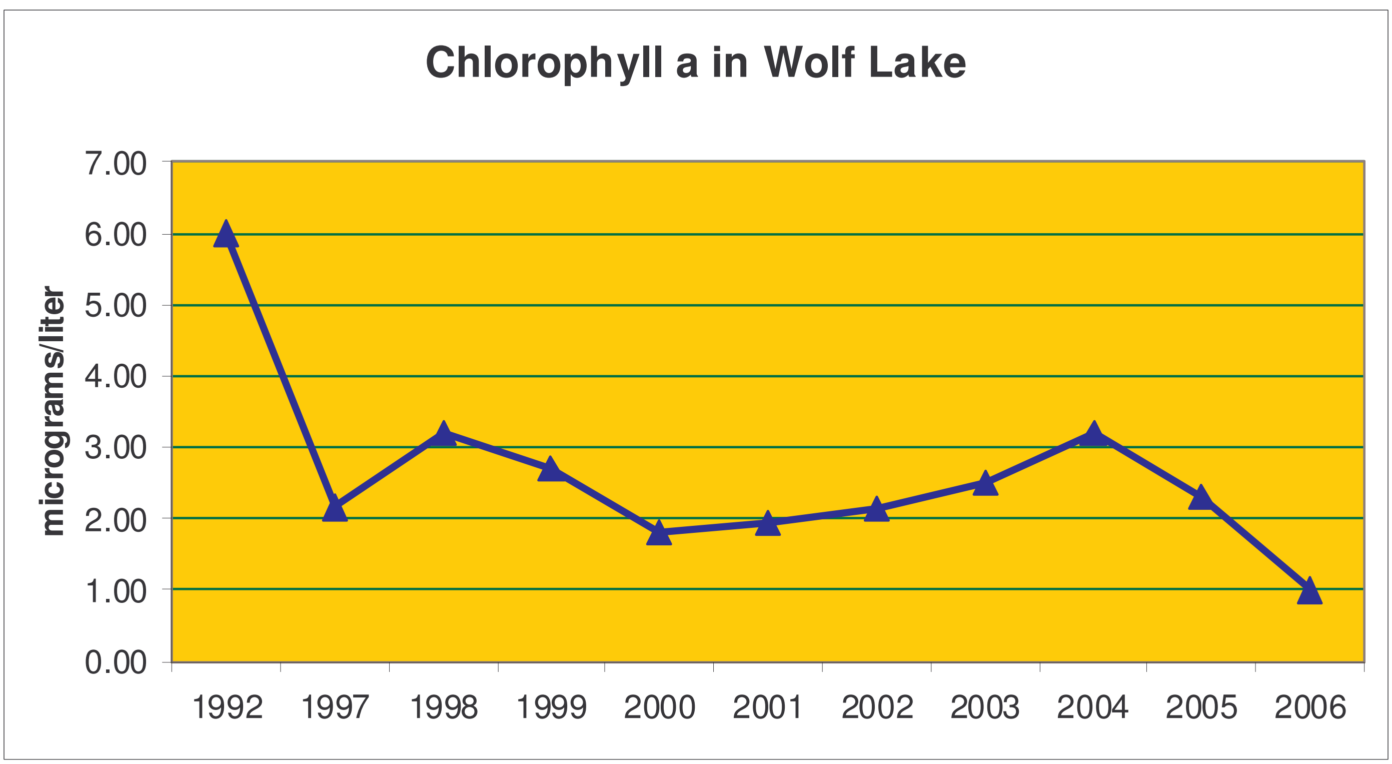
Figure 25: Photo of Testing Water Clarity with Secchi Disk

Chlorophyll a

Chlorophyll-a concentrations provide a measurement of the amount of algae in a lake's water. Algae are natural and essential in lakes, but high algal populations can increase water turbidity and reduce light available for plant growth, as well as result in unpleasing odor and appearance. Studies have shown that the amount of chlorophyll a in lake water depends greatly on the amount of algae present; therefore, chlorophyll-a levels are commonly used as a water quality indicator. **The 2004-2006 summer (June-September) average chlorophyll concentration in Wolf Lake was 2.8 ug/liter** This low algae concentration places Wolf Lake at the "oligotrophic" level for chlorophyll a results.

Chlorophyll-a averages have stayed low since 1992, the first year for which records were found, and have remained very low between 2004 and 2006, when the Adams County LWCD was monitoring the lake.

Figure 26: Summer Chlorophyll-a Averages

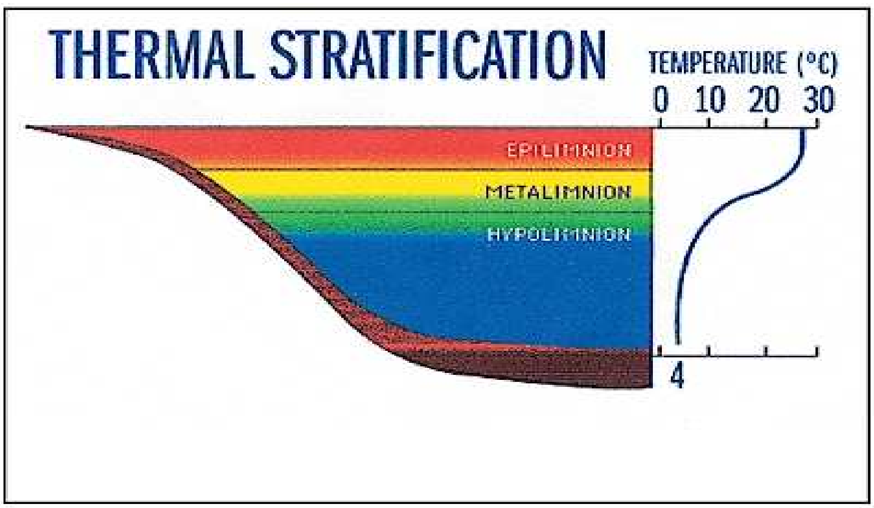


Dissolved Oxygen

Oxygen dissolved in the water is essential to all aerobic aquatic organisms. The oxygen in a lake comes from the atmosphere and from the process of photosynthesis. Aquatic plants and algae consume carbon dioxide and respirate oxygen back into the lake water. The distribution of oxygen within a lake is affected by many factors, including water circulation, water stratification, winds or storms, air temperature; water temperature, nutrient availability, and the density and location of algae and/or aquatic plants.

Oxygen consumption in the sediment and the water just above it (hypolimnion) is more sensitive that those in the two upper layers of water (metalimnion and epilimnion) because the bottom consumption is less likely to be balanced by the circulation and photosynthesis output available to the upper layers.

Figure 27: Lake Stratification Layers



Low oxygen during the summer in the bottom waters of a lake occurs naturally as oxygen in the bottom layer is consumed, but not replenished. It is common that as the summer progresses, the oxygen concentration of the bottom waters decreases. In Wolf Lake, there were hypoxic periods in the depths from 25' to 50' during the summers of 2004 and 2005. By the end of summer 2004 (September), oxygen concentration at 25' depth was only 2.5 mg/l and down to .3 mg/l at the 50' depth. And in 2005, by the end of August, oxygen concentration at 30' down is only .9 mg/l and 1.45 mg/l at 50' depth. This pattern was not present in 2006 when oxygen levels at all depths were over 5 mg/l (the minimum level for most fish survival).

The charts (Figures 28a, b, c) below show the annual (2004-2006) variations in dissolved oxygen levels in milligrams/liter, depth in feet and months of the year:

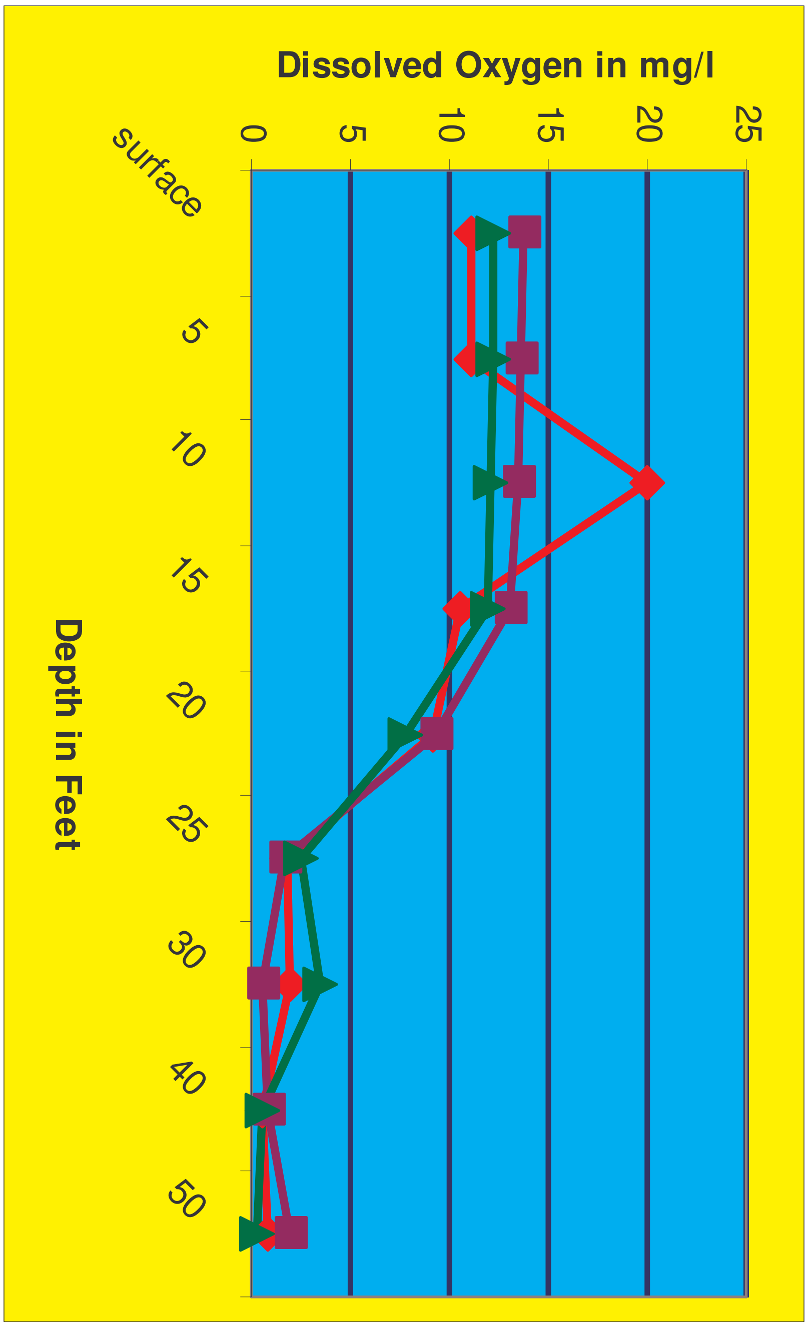


Figure 28a: Dissolved Oxygen Levels During 2004 Water Testing

6/04

8/04

9/04

Figure 28b: Dissolved Oxygen Levels During 2005 Water Testing

2/05

4/05

6/05

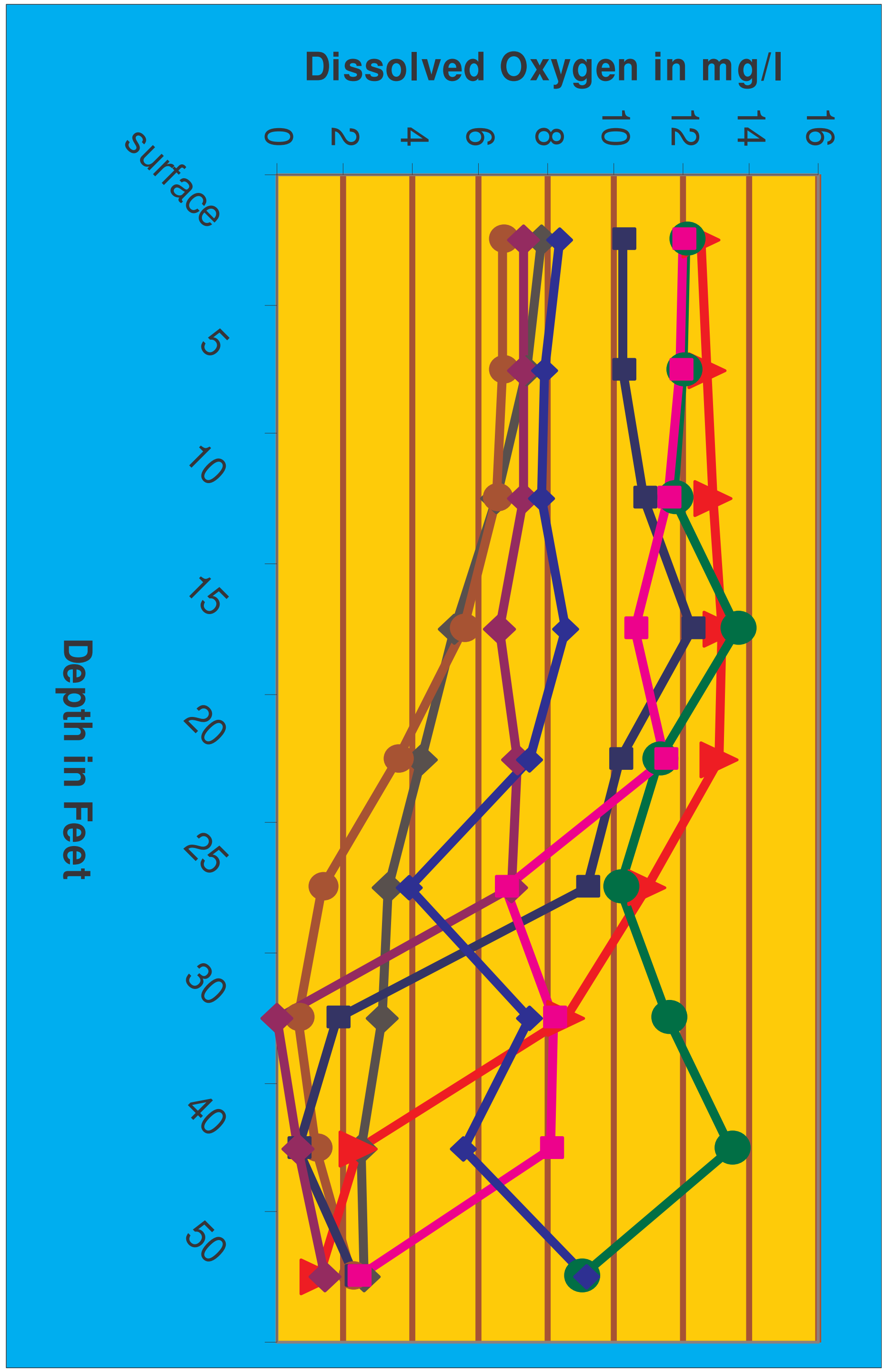
7/05

8/05

9/05

9/05

11/05



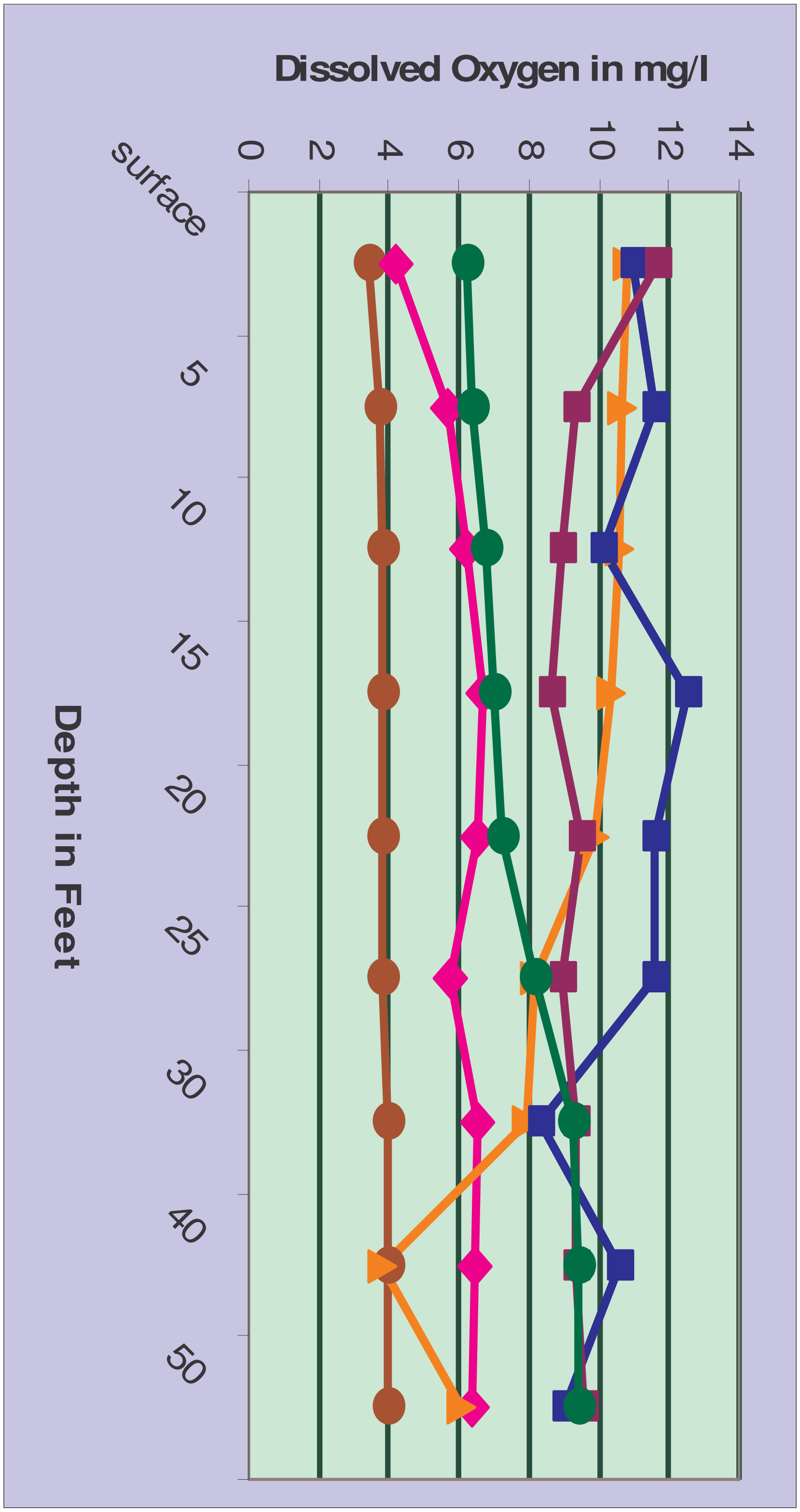


Figure28c: Dissolved Oxygen Levels During 2006 Water Testing

4/06

6/06

7/06

8/06

9/06

9/06

By autumn, when the surface waters have cooled and water density throughout the water column is the same, the water column mixes vertically, a process known as “fall turnover.”

Human activity can aggravate the development of low oxygen (hypoxic) or no oxygen (anoxic) in the bottom waters. For example, the addition of phosphorus usually leads to an increase in the growth of algae and aquatic plants—both of which consume oxygen during their photosynthesis. It has also been hypothesized that hypoxia or anoxia can be affected by climate changes, such as a longer and/or warmer summer, low lake levels, and changes in water temperature due to cover (i.e., shore vegetation) being removed.

The development of hypoxia or anoxia can have negative effects. The first effect usually noticed by human is fish kills. Fish kills result when fish species that need cold oxygen-rich water to survive can’t find it in the lake anymore or when some of their invertebrate food (such as mayfly nymphs) is gone due to low oxygen levels. Another noticeable effect can be an increase in the frequency and distribution of algal blooms. In some instances, anoxia can lead to blooms of toxic algae and the production of water-borne toxins that can harm humans and wildlife. Anoxia sometimes also leads to increased phosphorus cycling, undesirable water taste or odor levels, and interference with recreational uses such as swimming, boating and fishing.

As noted above, summer hypoxia or anoxia can result in phosphorus being released into the upper water column and being available for algal blooms and increased aquatic plant growth. The results from 2004 through 2006 (the only years for which data is available) don’t show that summer hypoxia/anoxia in the lower depths is always a problem in Wolf Lake, but it did show up in two of the three years.

The data from 2004-2006 (see Figures 28a, b, c) shows there is potential for phosphorus loading from the lower depths (hypolimnion) during the summer months in Wolf Lake if the hypoxia/anoxia continues. Dissolved oxygen needs to be monitored during the late summer months in the lower depths on Wolf Lake to determine whether hypoxia/anoxia is a frequently-occurring condition that may need to be addressed by management practices.

Figure 29: Photo of a Lake with Algal Bloom

Water Hardness, Alkalinity and pH

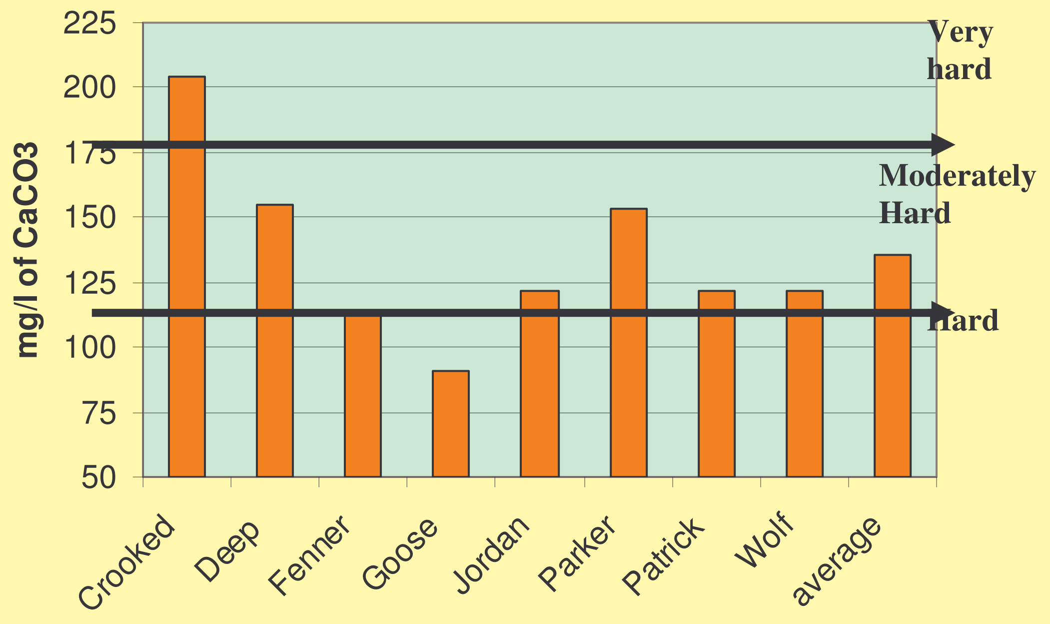
Testing done by Adams County LWCD on Wolf Lake included annual testing for water alkalinity and water hardness. Hardness and alkalinity levels in a lake are affected by the soil minerals, bedrock type in the watershed, and frequency of contact between lake water & these materials.

Level of Hardness	Mg/l CaCO3
SOFT	0-60
MODERATELY HARD	61-120
HARD	121-180
VERY HARD	>180

Figure 30: Levels of Hardness in Mg/l of Calcium Carbonate

One method of evaluating hardness is to test the water for the amount of calcium carbonate (CaCO3) it contains. The surface water of all of the public access lakes in Adams County have water that is moderately hard to very hard, whether they are impoundments (man-made lakes) or natural lakes. In 2005 and 2006, random samples were also taken of wells around Wolf Lake to measure the hardness of the water coming into the lake through groundwater. Hardness in the groundwater ranged from 140 (hard) to 356 (very hard). The hardness in both surface and groundwater is likely due to the underlying bedrock in Adams County, which is mostly sandstone with pockets of dolomite and shale.

Figure 31: Hardness of Adams County Natural Lakes



As the graph (Figure 31) shows, Wolf Lake testing results showed “hard” water (122 mg/l CaCO3), although Wolf Lake’s hardness is less than the hardness average for The average hardness for natural lakes in Adams County was 135 mg/l o Calcium Carbonate. Hard water lakes tend to produce more fish and aquatic plants than soft water lakes because they are often located in watersheds with soils that load phosphorus into the lake water.

However, hard water lakes also often have marl sediments that precipitate the phosphorus out, serving to help balance the phosphorus loaded from the watershed. Hardness levels over 180 mg/l can cause marl to start precipitating out of the water or sediment, thus releasing phosphorus for aquatic plant and algae use. But since Wolf Lake’s hardness less is far below that, the marl in the lake is likely to keep binding a significant amount of phosphorus that would otherwise be in the water column.

Alkalinity is important in a lake to buffer the effects of acidification from the atmosphere. “Acid rain” has long been a problem with lakes that had low alkalinity level and high potential sources of acid deposition.

Acid Rain Sensitivity	ueq/l CaCO3
High	0-39
Moderate	49-199
Low	200-499
Not Sensitive	>500

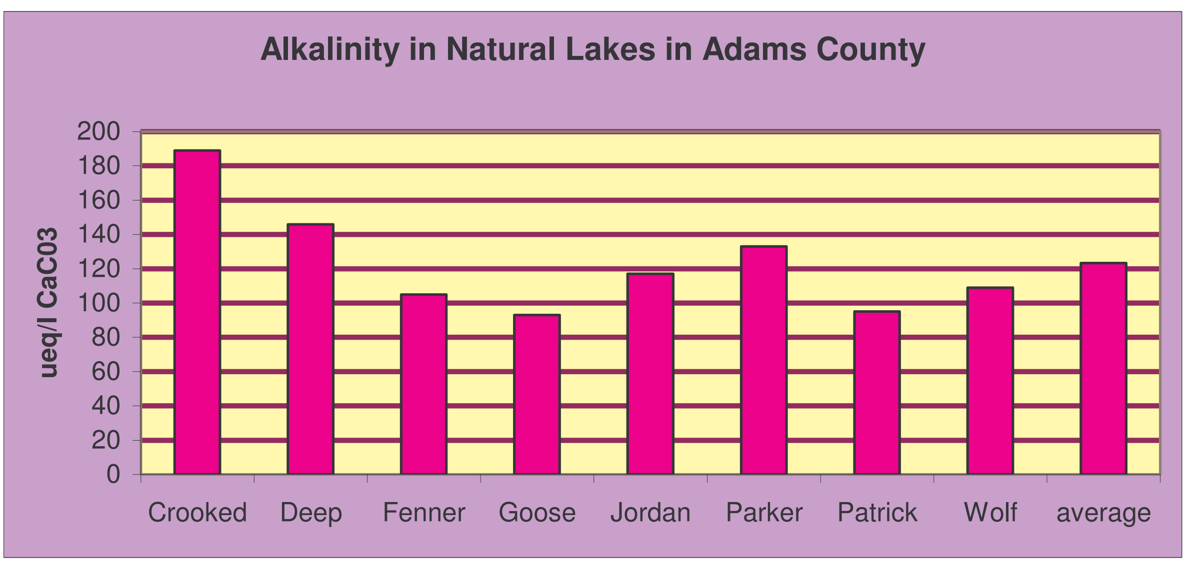
Figure 32: Acid Rain Sensitivity

Well water testing results ranged from 140 ueq/l to 340 ueq/l in alkalinity, higher than the surface water results. Wolf Lake's potential sensitivity to acid rain is moderate, but luckily for Adams County, the acid deposition rate is very low, probably due to the little industrialization in the county.

Alkalinity also affects the pH level of lake water. The acidity level of a lake's water regulates the solubility of many minerals. A pH level of 7 is neutral. The pH level in Wisconsin lakes ranges from 4.5 in acid bog lakes to 8.4 in hard water, marl lakes.

Some of the minerals that become available under low pH, especially the metals aluminum, zinc and mercury, can inhibit fish reproduction and/or survival. Even what seems like a small variance in pH can have large effects because the pH scale is set up so that every 1.0 unit change increases acidity tenfold, i.e., water with a pH of 7 is 10 times more acid than water with pH of 8. Mercury and aluminum are not only toxic to many kinds of wildlife; they can also be toxic to humans, especially those that eat tainted fish.

Figure 33: Alkalinity in Natural Lakes in Adams County



The testing occurring from 2004-2006 also included regular monitoring of the pH at several depths in Wolf Lake. As is common in the lakes in Adams County, Wolf Lake has pH levels starting at just under neutral (6.33) at 50’ depth and increasing in alkalinity as the depth gets less, until the surface water pH averages 7.72. A lake’s pH level is important for the release of potentially harmful substances and also affects plant growth, fish reproduction and survival. Most plants grow best at pH levels between 5.5 and 8.

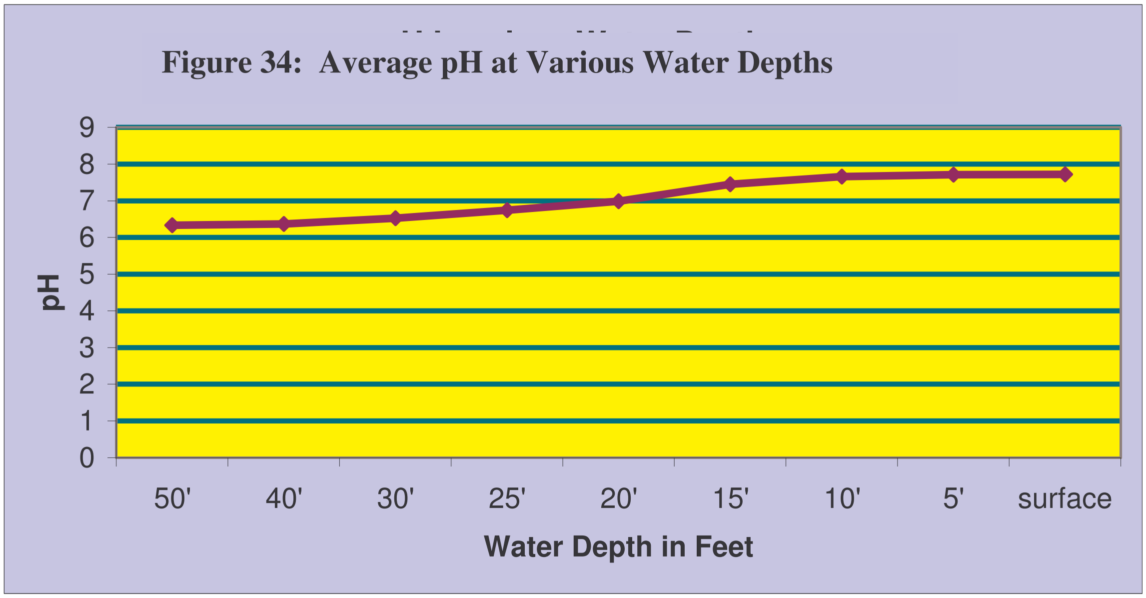


Figure 34: Average pH at Various Water Depths

More importantly for many lakes, fish reproduction and survival are very sensitive to pH levels. The chart below indicates the effect of pH levels under 6.5 on fish (Figure 35):

Figure 35: Effects of pH Levels on Fish

Water pH	Effects
6.5	walleye spawning inhibited
5.8	lake trout spawning inhibited
5.5	smallmouth bass disappear
5.2	walleye & lake trout disappear
5	spawning inhibited in most fish
4.7	Northern pike, sucker, bullhead, pumpkinseed, sunfish & rock bass disappear
4.5	perch spawning inhibited
3.5	perch disappear
3	toxic to all fish

Although pH levels at the 30’-50’ depths in Wolf Lake sometimes fall below the pH level that inhibits walleye reproduction, spawning tends to occur in shallower waters where Wolf Lake has a good pH level for fish reproduction and survival.

A lake with a neutral or slightly alkaline pH like Wolf Lake is a good lake for fish and plant survival. Natural rainfall in Wisconsin averages a pH of 5.6. This means that if the rain falls on a lake without sufficient alkalinity to buffer that acid water coming in by rainfall, the lake's fish cannot reproduce. That is not a problem at Wolf Lake.

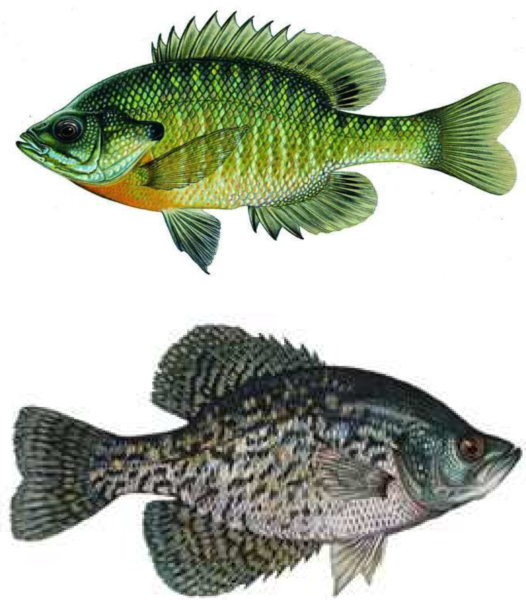


Figure 36: Common Fish in Wolf Lake: Bluegill (top) and Crappie (bottom)

Other Water Quality Testing Results

CALCIUM and MAGNESIUM: Calcium is required by all higher plants and some microscopic lifeforms. Magnesium is needed by chlorophyllic plants and by algae, fungi and bacteria. Both calcium and magnesium are important contributors to the hardness of a lake's waters. Magnesium elevated about 125 mg/l may have a laxative effect on some humans. Otherwise, no health hazards to humans and wildlife are known from calcium and magnesium. The average Calcium level in Wolf Lake's water during the testing period was 22.2 mg/l. The average Magnesium level was 14.74 mg/l. Both of these are low-level readings.

CHLORIDE: Chloride does not affect plant and algae growth and is not known to be harmful to humans. It isn't common in most Wisconsin soils and rocks, so is usually found only in very low levels in Wisconsin lakes. However, the presence of a significant amount of chloride over a period of time indicates there may be negative human impacts on the water quality present from septic system failure, the presence of fertilizer and/or waste, deposition of road-salt, and other nutrients. An increased chloride level is thus an indication that too many nutrients are entering the lake, although the level has to be evaluated compared to the natural background data for chloride. The chloride levels found in Wolf Lake during the testing period were all below 3 mg/l, or about the natural level of chloride in this area of Wisconsin.

NITROGEN: Nitrogen is necessary for plant and algae growth. A lake receives nitrogen in various forms, including nitrate, nitrite, organic, and ammonium. In Wisconsin, the amount of nitrogen in a lake's water often corresponds to the local land use. Although some nitrogen will enter a lake through rainfall from the atmosphere, that coming from land use tends to be in higher concentrations in larger amounts, coming from fertilizers, animal and human wastes, decomposing organic matter, and surface runoff. For example, the growth level of the exotic aquatic plant, Eurasian Watermilfoil (*Myriophyllum spicatum*) has been correlated with fertilization of lake sediment by nitrogen-rich spring runoff.

Nitrogen levels can affect other aspects of water quality. The sum of water testing results for nitrate, nitrite and ammonium levels of over .3 mg/l in the spring can be used to project the likelihood of an algal bloom in the summer (assuming sufficient phosphorus is also present). Wolf Lake combination spring levels from 2004 to 2006 never rose to more than .13 mg/l, far below the .3 mg/l predictive level for algal blooms.

SODIUM AND POTASSIUM: These elements occur naturally only in low levels in Wisconsin waters and soils. Their presence may indicate human-caused pollution. Sodium is found with chloride in many road salts and fertilizers and is also found in human and animal waste. Potassium is found in many fertilizers and also found in animal waste. The level of these two is generally not useful as a specific pollution indicator, but increasing levels or one or both of these elements can indicate possible contamination from damaging pollutants. High levels of sodium have also been found to influence the development of a large population of cyanobacteria, some of which can be toxic to animals and humans. Some health professionals have suggested that sodium levels over 20 mg/l may be harmful to heart and kidney patients if ingested.

Both sodium and potassium levels in Wolf Lake are very low: the average sodium level was 1.98 mg/l; the average potassium reading was .13 mg/l.

SULFATE: In low-oxygen waters (hypoxic), sulfate can combine with hydrogen and becomes the gas hydrogen sulfate (H2S), which smells like rotten eggs and is toxic to most aquatic organisms. Sulfate levels can also affect the metal ions in the lake, especially iron and mercury, by binding them up, thus removing them from the water column.

To prevent the formation of H2S, levels of 10 mg/l are best. A health advisory kicks in at 30 mg/l. Wolf Lake sulfate levels average 3.61 mg/l during the testing period, far below either level.

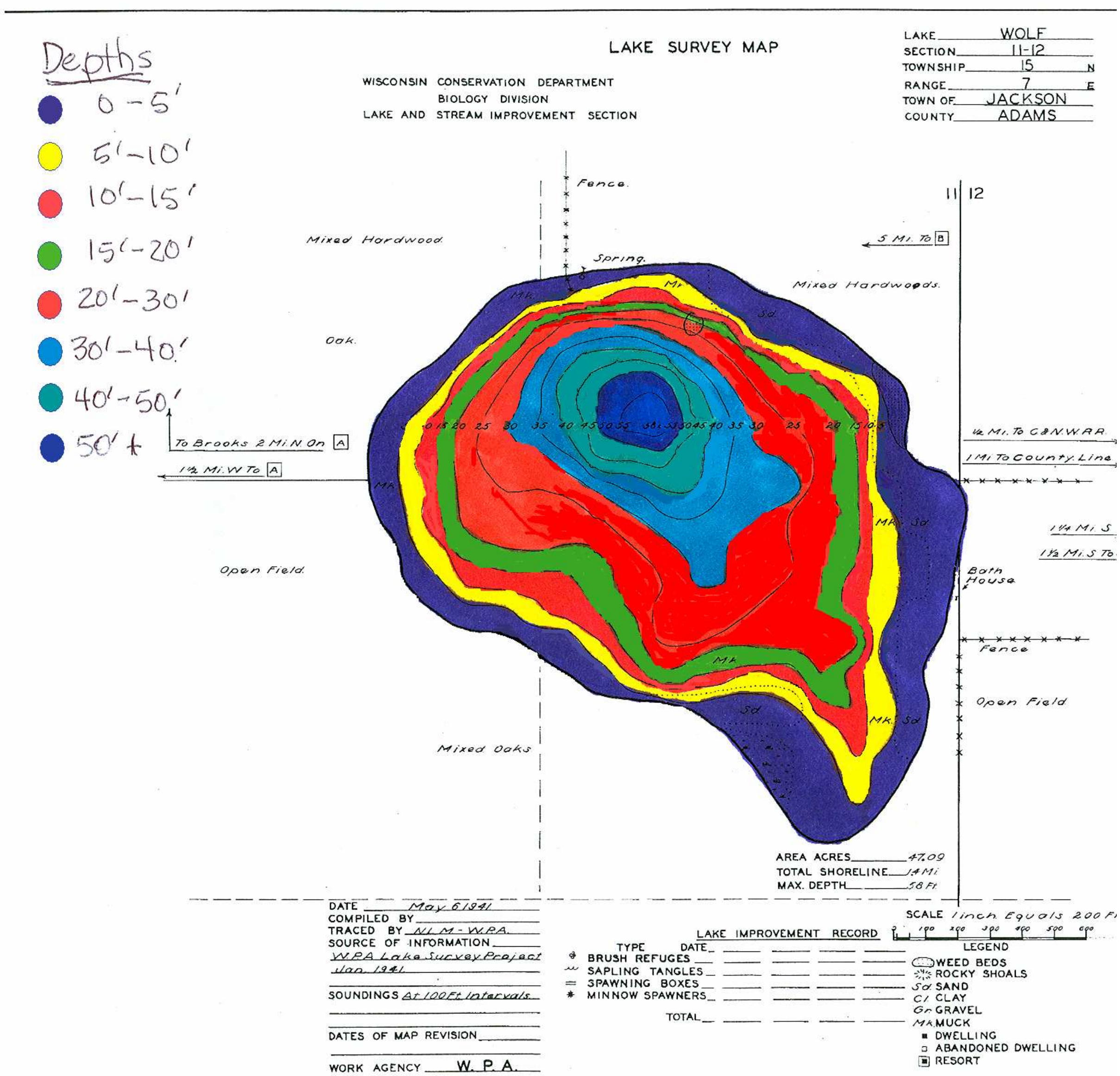
TURBIDITY: Turbidity reflects water clarity. The term refers to suspended solids in the water column—solids that may include clay, silt, sand, plankton, waste, sewage and other pollutants. Turbid water may mask the presence of bacteria or other pollutants because the water looks murky or muddy. In general, turbidity readings of less than 5 NTU are best. Very turbid waters may not only smell, but also tend to be aesthetically displeasing, thus curtailing recreational uses of the water. Turbidity levels for Wolf Lake's waters were 1.85 NTU in 2004, 1.5 NTU in 2005, and 1.9 NTU in 2006—all very low levels.

Figure 37: Examples of Very Turbid Water

HYDROLOGIC BUDGET

Wolf Lake has a surface area of **49 acres.** According to the 1941 bathymetric (depth) map (the most recent one available), the volume of the lake is **1237.5 acre-feet**, and the mean depth is **25.3 feet**. The maximum depth is 58 feet.

Figure 38: Wolf Lake Bathymetric Map

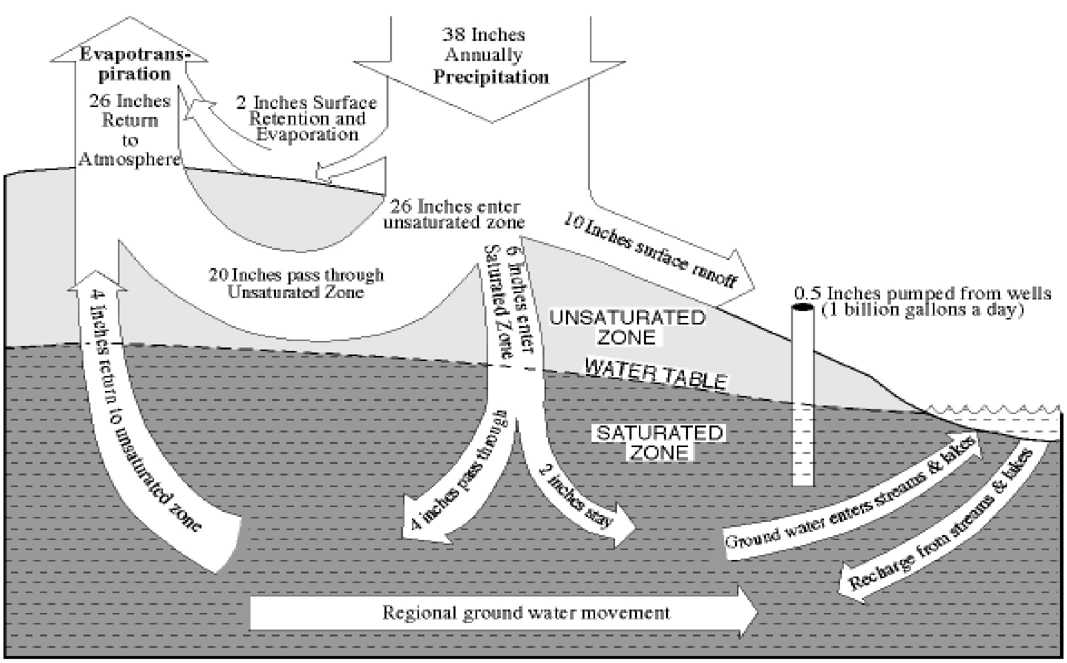


A "hydrologic budget" is an accounting of the inflow to, outflow from and storage in a hydrological unit (such as a lake). "Residence time" is the average length of time particular water stays within a lake before leaving it. This can range from several days to years, depending on the type of lake, amount of rainfall, and other factors. "Flushing rate" is the time it takes a lake's volume to be replaced. "Annual runoff volume", as used in WiLMS, is the total water yield from the drainage area reaching the lake. The "drainage area" is the amount of area (in acres) contributing surface water runoff and nutrients to the lake. The "areal water load" is the total annual flow volume reaching the lake divided by the surface area of the lake. "Hydraulic loading" is the total annual volume of all water sources (including precipitation, non-point sources & point sources) loading into the lake.

Using the data gathered from historical testing and that done by the Adams County LWCD from 2004-2006, the WiLMS model calculated the tributary drainage area for Wolf Lake as **915.2 acres.** The average unit runoff for Adams County in the Wolf Lake area is 9.4 inches. WiLMS determined the expected annual runoff volume as **716.9 acre-feet/year.** Anticipated annual hydraulic loading is **727.5 acre-feet/year**. Areal water load is **14.8 feet/year.**

In a seepage lake like Wolf Lake, water and its nutrient load tend to stay longer within the lake before leaving it than in a lake with an inlet and/or outlet—in Wolf Lake's case, modeling estimates a water residence of **1.7 years.** The calculated lake flushing rate is .**59 per year.**

Figure 39: Example of Hydrologic Budget



TROPHIC STATE

The trophic state of a lake is one measure of water quality, basically defining the lake's biological production status. (See Figure 40). **Eutrophic lakes** are very productive, with high nutrient levels, frequent algal blooms and/or abundant aquatic plant growth. **Oligotrophic lakes** are those low in nutrients with limited plant growth and small populations of fish. **Mesotrophic lakes** are those in between, i.e., those which have increased production over oligotrophic lakes, but less than eutrophic lakes; those with more biomass than oligotrophic lakes, but less than eutrophic lakes; often with a more varied fishery than either the eutrophic or oligotrophic lakes. In comparing water quality testing results with the prediction from the computer modeling of this modeling with the actual figures outlined above, the actual Trophic State of Wolf Lake is what was predicted from the modeling. Modeling results predicted that the overall TSI for Wolf Lake would be **42**. This score places Wolf Lake's overall TSI at about average for natural lakes in Adams County.

Figure 40: Trophic Status Table

Wolf Lake = 42

Score	TSI Level Description
30-40	**Oligotrophic:** clear, deep water; possible oxygen depletion in lower depths; few aquatic plants or algal blooms; low in nutrients; large game fish usual fishery
40-50	**Mesotrophic:** moderately clear water; mixed fishery, esp. panfish; moderate aquatic plant growth and occasional algal blooms; may have low oxygen levels near bottom in summer
50-60	**Mildly Eutrophic:** decreased water clarity; anoxic near bottom; may have heavy algal bloom and plant growth; high in nutrients; shallow eutrophic lakes may have winterkill of fish; rough fish common
60-70	**Eutrophic:** dominated by blue-green algae; algae scums common; prolific aquatic plant growth; high nutrient levels; rough fish common; susceptible to oxygen depletion and winter fishkill
70-80	**Hypereutrophic:** heavy algal blooms through most of summer; dense aquatic plant growth; poor water clarity; high nutrient levels

Phosphorus concentration, chlorophyll-a concentration and water clarity data are collected and combined to determine a trophic state. As discussed earlier, the average summer epilimnetic total phosphorus for Wolf Lake was 17.3 micrograms/liter. The average summer chlorophyll-a concentration was 2.8 micrograms/liter. Growing season water clarity averaged a depth of 13.63 feet. Figure 40 shows where each of these measurements from Wolf Lake fall in trophic level.

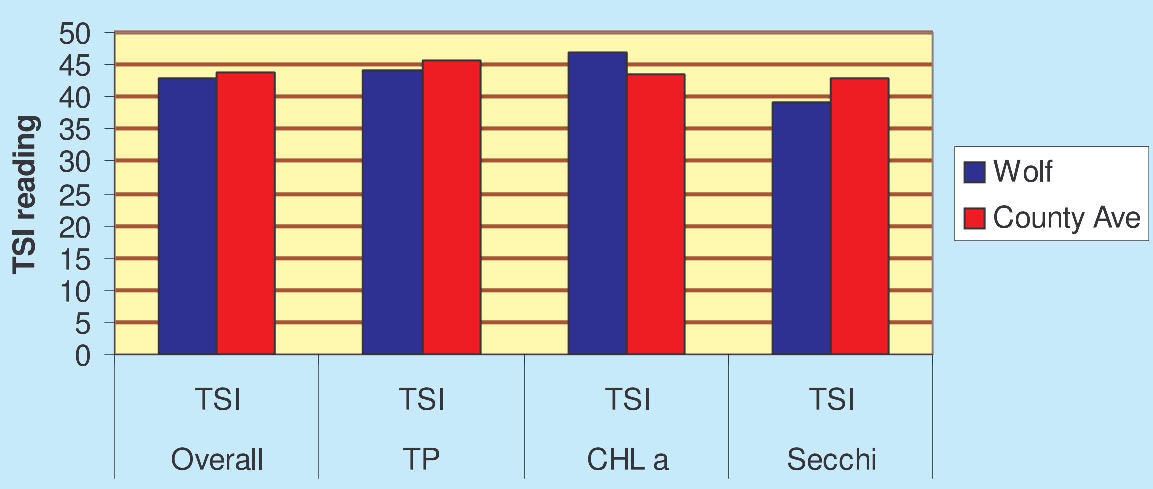
Figure 41: Wolf Lake Trophic Status Overview

Trophic State	Quality Index	Phosphorus	Chlorophyll a	Sechhi Disk
		(ug/l)	(ug/l)	(ft)
Oligotrophic	Excellent	<1	<1	>19
	Very Good	1 to 10	**1 to 5**	**8 to 19**
Mesotrophic	Good	**10 to 30**	5 to 10	6 to 8
	Fair	30 to 50	10 to 15	5 to 6
Eutrophic	Poor	50 to 150	15 to 30	3 to 4
Wolf Lake		**17.3**	**2.8**	**13.63**

These figures show that Wolf Lake has low levels overall for the three parameters often used to described water quality: Secchi disk depths; average TP for the growing season; and chlorophyll a levels. It is normal for all of these values to fluctuate during a growing season. However, they can be affected by human use of the lake, by summer temperature variations, by algae growth & turbidity, and by rain or wind events.

According to these results, Wolf Lake scores as **"mesotrophic"** in its phosphorus level, and "**oligotrophic**" in chlorophyll-a readings, and Secchi disk readings. With such phosphorus readings and chlorophyll a readings, dense plant growth and frequent algal blooms would not be expected.

Figure 42: Trophic State Index for Wolf Lake



IN-LAKE HABITAT

Aquatic Plants

A healthy aquatic plant community plays a vital role within the lake community. This is due to the role plants play in improving water quality, providing valuable habitat resources for fish and wildlife, resisting invasions of non-native species and checking excessive growth of the most tolerant species.

An aquatic plant survey was done on Wolf Lake in the summer of 2005 by staff from the WDNR and the Adams County LWCD. The results verified that Wolf Lake is an oligotrophic lake with very good water quality and excellent water clarity, although nutrient level and algae frequency have increased since 1997. Filamentous algae are common in Wolf Lake, abundant in the 5-10ft depth zone.

The aquatic plant community colonized approximately half of Wolf Lake, with 100% of the littoral zone covered to a maximum rooting depth of 17.5 feet. The 0 to 1.5 foot depth zone supported the most abundant aquatic plant growth. The Wolf Lake aquatic plant community is characterized by high quality and excellent species diversity. The plant community has a below average sensitivity to disturbance and is closer to an undisturbed condition than the average lake in the state.

Chara spp. and *Elodea canadensis* were the co-dominant species. *Najas guadalupensis* was sub-dominant. The most common species (except Eurasian watermilfoil) were found distributed throughout the lake. Eurasian watermilfoil was a commonly occurring species, but occurred at below average densities and was abundant only at depths greater than 10 feet.

Figure 43:
Comandra umbellate
(Bastard Toadflax)—
one of Wolf Lake
wetland's more
unusual plants

Figure 44: Wolf Lake Aquatic Plant Species 2005

Scientific Name	Common Name
Emergent Species	
1) *Calamagrostis canadensis* (Michx.) P.Beauv.	bluejoint grass
2) *Carex* spp.	sedge
3) *Eleocharis smallii* Britt.	creeping spikerush
4) *Scirpus validus* Vahl.	softstem bulrush
5) *Typha angustifolia* L.	narrow-leaf cattail
6) *Typha latifolia* L.	common cattail
Floating-leaf Species	
7) *Nymphaea odorata* Aiton.	white water lily
8) *Polygonum amphibium* L.	water smartweed
Submergent Species	
9) *Ceratophyllum demersum* L.	coontail
10) *Chara* sp.	muskgrass
11) *Eleocharis acicularis* (L.) R & S.	needle spikerush
12) *Elodea canadensis* Michx.	common waterweed
13) *Myriophyllum heterophyllum* Michx.	variable-leaf water-milfoil
14) *Myriophyllum sibiricum* Komarov.	common water milfoil
15) *Myriophyllum spicatum* L.	Eurasian water milfoil
16) *Najas guadalupensis* (Spreng.) magnus.	common water-nymph
17) *Nitella* sp.	nitella
18) *Potamogeton amplifolius* Tuckerman.	large-leaf pondweed
19) *Potamogeton crispus* L.	curly-leaf pondweed
20) *Potamogeton foliosus* Raf.	leafy pondweed
21) *Potamogeton gramineus* L.	variable-leaf pondweed
22) *Potamogeton illinoensis* Morong.	Illinois pondweed
23) *Potamogeton natans* L.	floating-leaf pondweed
24) *Potamogeton pectinatus* L.	sago pondweed
25) *Potamogeton pusillus* L.	small pondweed
26) *Potamogeton praelongus* Wulf.	white-stem pondweed
27) *Potamogeton richardsonii* (Ar. Benn.) Rydb.	clasping-leaf pondweed
28) *Potamogeton robbinsii* Oakes.	fern-leaf pondweed
29) *Potamogeton zosteriformis* Fern.	flatstem pondweed
30) *Ranunculus longirostris* Godron.	white watercrowfoot
31) *Sagittaria* spp.	arrowhead rossettes
32) *Zosterella dubia* (Jacq.) Small	water stargrass

The study used the results of the 2005 field survey to evaluate Wolf Lake by using several standard community measurements. For example, the Simpson's Diversity Index was 0.92, indicating excellent species diversity. A rating of 1.0 would mean that each plant in the lake was a different species (the most diversity achievable).

The Aquatic Macrophyte Community Index (AMCI) for Wolf Lake is 61. This is in the upper quartile of lakes in Wisconsin and the North Central Hardwoods Region of the state. This value places Wolf Lake in the top 25% of lakes in the state and region with the highest quality aquatic plant communities.

The Average Coefficient of Conservatism for Wolf Lake was 5.5, below average for Wisconsin lakes (6.0) and lakes in the North Central Hardwood (5.6) Region. This suggests that the aquatic plant community in Wolf Lake is less sensitive to disturbance than the average lake in the state or region. This is likely due to selection of species by past disturbance.

The Floristic Quality Index of the aquatic plant community in Wolf Lake was 29.10, in the upper quartile of Wisconsin lakes (average 22.2) and North Central Hardwood Region lakes (average 20.9). This indicates that the plant community in Wolf Lake is within the group of lakes in the state and region closest to an undisturbed condition.

Comparisons were also made between developed and natural shorelines on Wolf Lake. In looking at those results, the Average Coefficient of Conservatism was higher at the natural shoreline communities. Filamentous algae had a much higher occurrence at sites at disturbed shoreline as compared to natural shoreline.

Eurasian watermilfoil, a non-native, invasive plant species, is a critical threat to habitat and native plant species. Results from the 2005 survey show it had a much higher occurrence and mean density at disturbed shoreline sites on Wolf Lake. Also, at sites where it was present, it had a denser growth form at the disturbed sites. Two other non-native, exotic species (curly-leaf pondweed and narrow-leaf cattail) occurred only at disturbed shoreline sites. Disturbance creates an ideal condition for exotic species to colonize and spread.

Conversely, the most sensitive species in Wolf Lake (Nichols 2000), *Potamogeton praelongus* (White-Stemmed Pondweed) occurred at a much higher frequency, grew at a higher density and had a higher dominance at the sites near natural shoreline. This corroborates the impact disturbed shoreline has on the aquatic plant community.

Plant distribution, frequency and density varied considerably within Wolf Lake, depending on the plant types (see Figure 45).

Figure 45: Aquatic Plants in Wolf Lake 2005

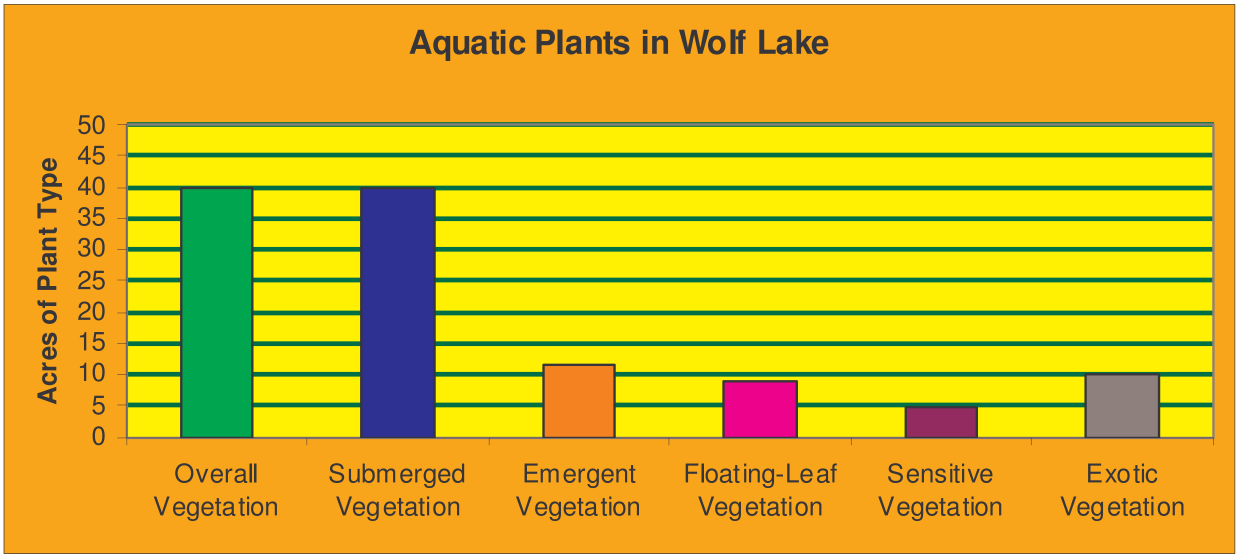


Figure 46a: Emergent Aquatic Plants in Wolf Lake 2005

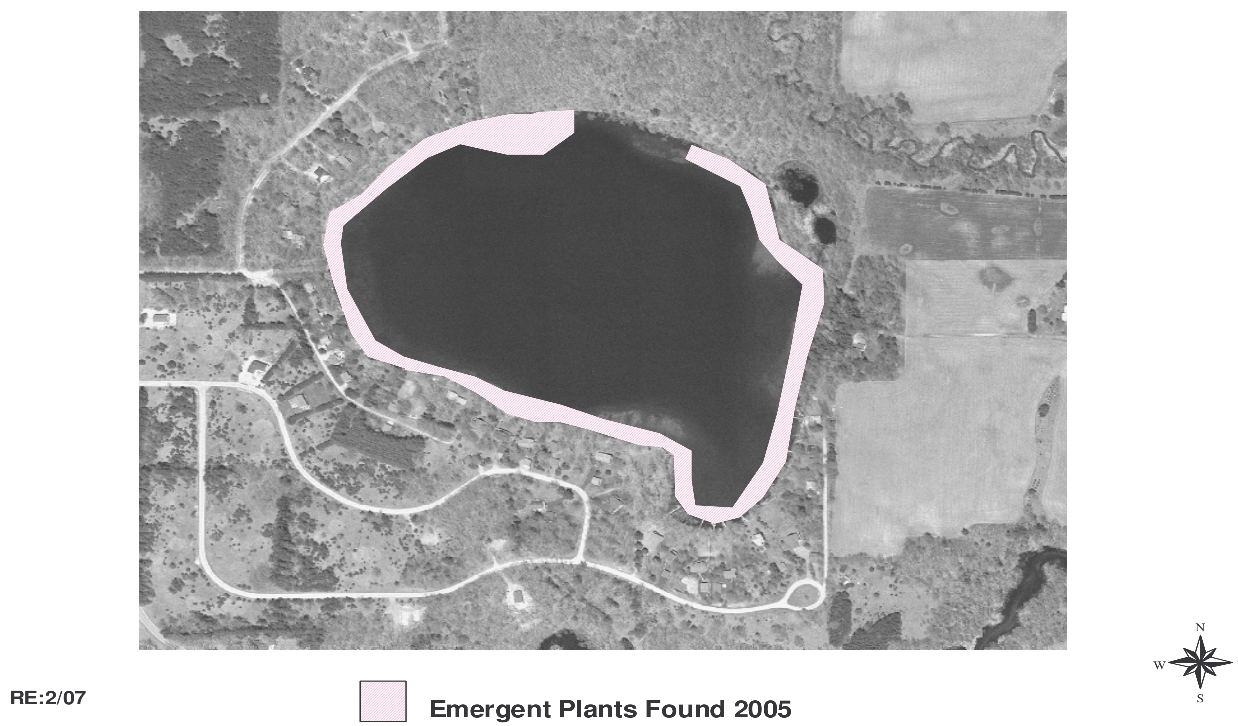


Figure 46b: Floating-Leaf Aquatic Plants in Wolf Lake 2005

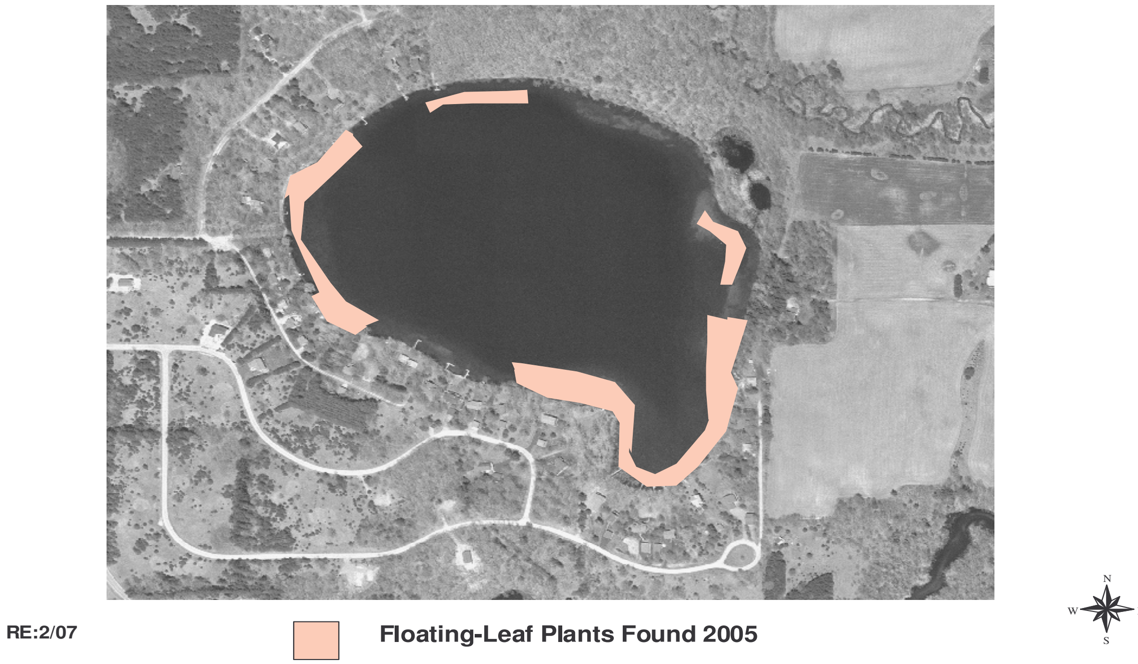
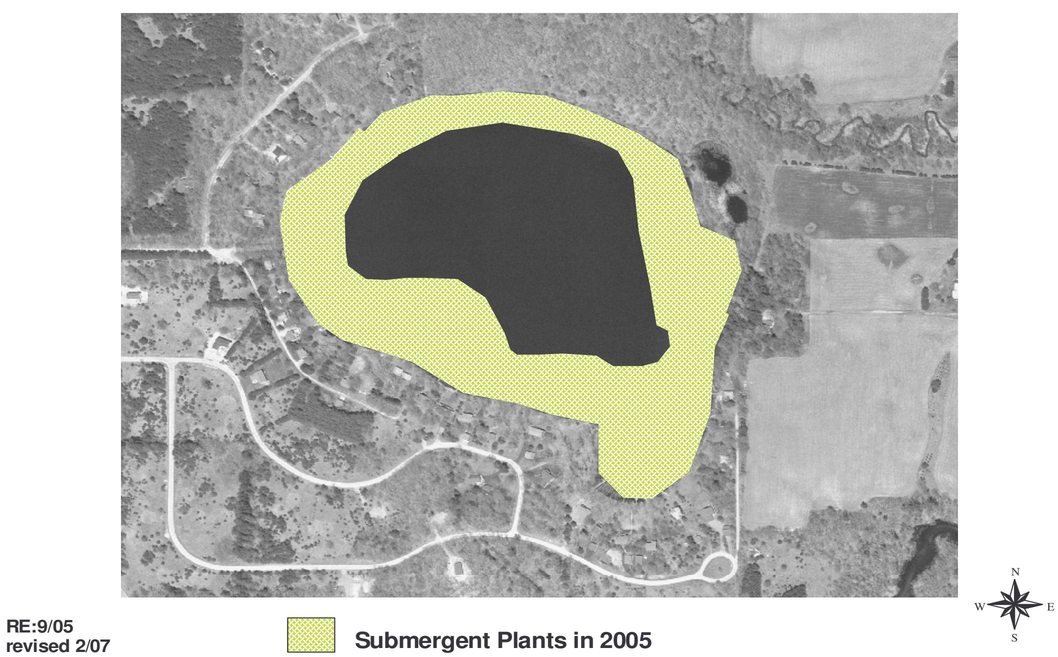
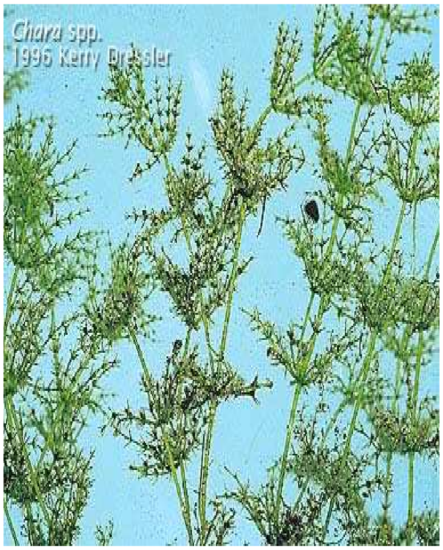


Figure 46c: Submergent Aquatic Plants in Wolf Lake 2005

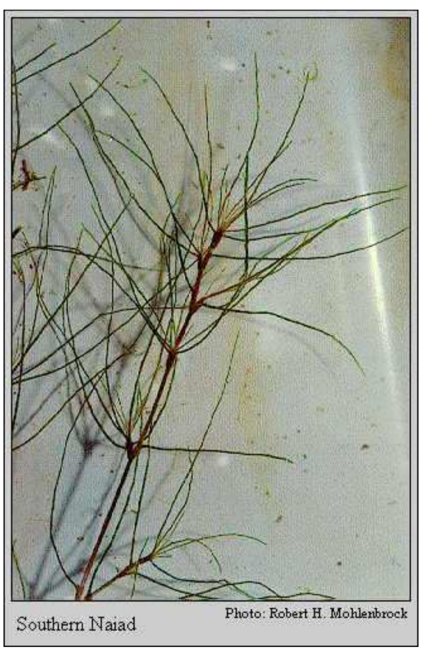




Chara spp (Muskgrass)

Figure 47: Most Common Native Aquatic Species in Wolf Lake

***Najas guadelupenis* (Southern Naiad)**



***Elodea canadensis* (Common Waterweed)**

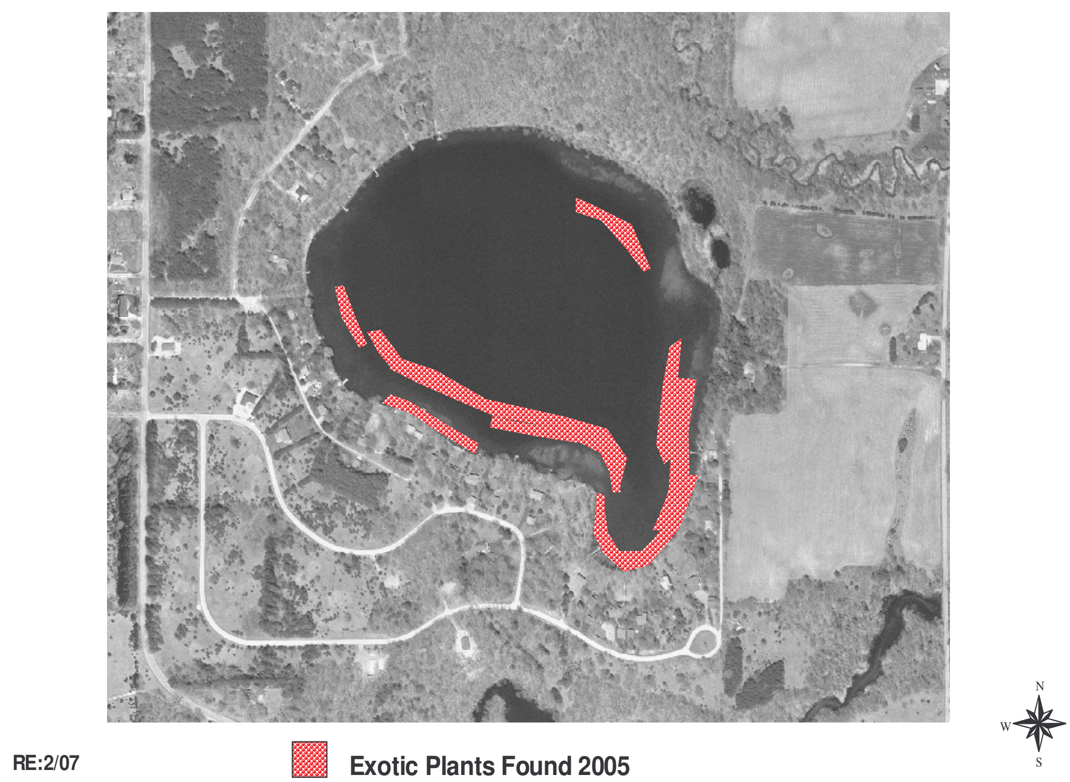
***Potamogeton pectinatus* (Sago Pondweed)**

Aquatic Invasives

Eurasian Watermilfoil was introduced in Wolf Lake, but since chemical treatments (targeting milfoil wherever it is found in the lake) began in 2002, the acreage of milfoil requiring treatment has declined. In July 2005, Eurasian Watermilfoil was a commonly occurring species, but occurred at below average densities and was abundant only at depths greater than 10 feet, occurring at the maximum rooting depth between 10' and 20' depth with *Elodea canadensis*. It was not found along the north shore. Its recurrence in the deeper areas and coverage of approximately 8 acres by July 2005 is likely due to the problem of decreasing chemical effectiveness with deeper water. The Wolf Lake Association expects to continue monitoring the Eurasian Watermilfoil population and take necessary treatment steps to keep it managed.

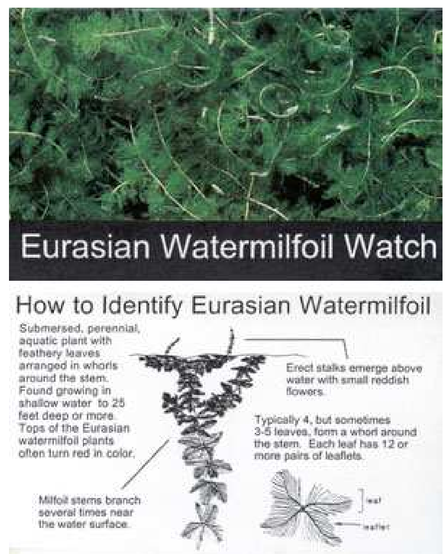
In addition, a survey in 2007 indicated that the native weevil, *Euhrychiopsis lecontei*, was present in parts of Wolf Lake. This weevil, if present in sufficient density, can weaken Eurasian milfoil plants to the point of death.

Figure 48: Distribution of Exotic Aquatic Plants in 2005



Curly-Leaf Pondweed was also found in Wolf Lake in 2005, but only at two sites in water 10' to 20' deep. Although it is present, it does not appear in either high frequency or density. Purple Loosestrife was also found on the shore of Wolf Lake in 2005—two plants were noted at one shore site just to the left of the boat ramp entry. Members of the Wolf Lake Association were notified of its presence. They pulled the plants by hand, being sure to remove all parts of the plant. It does not appear that Purple Loosestrife is a significant problem at Wolf Lake at this time. However, ongoing monitoring for both of these plants should occur.

Potamogeton crispus
(Curly-Leaf Pondweed)



Myriophyllum spicatum
(Eurasian Watermilfoil)

Figure 49: Two Most Common Invasive Aquatic Plants in Wolf Lake

Critical Habitat

Designation of critical habitat areas within lakes provides a holistic approach for assessing the ecosystem and for protecting those areas in and near a lake that are important for preserving the qualities of the lake. Wisconsin Rule 107.05(3)(i)(I) defines a “critical habitat areas” as: “areas of aquatic vegetation identified by the department as offering critical or unique fish & wildlife habitat or offering water quality or erosion control benefits to the body of water. Thus, these sites are essential to support the wildlife and fish communities. They also provide mechanisms for protecting water quality within the lake, often containing high-quality plant beds. Finally, critical habitat areas often can provide the peace, serenity and beauty that draw many people to lakes.

Protection of critical habitat areas must include protecting the shore area plant community, often by buffers of native vegetation that absorb or filter nutrient & stormwater runoff, prevent shore erosion, maintain water temperature and provide important native habitat. Buffers can serve not only as habitats themselves, but may also provide corridors for species moving along the shore.

Figure 50: WILD BOG ORCHID AT WOLF LAKE IN 2006

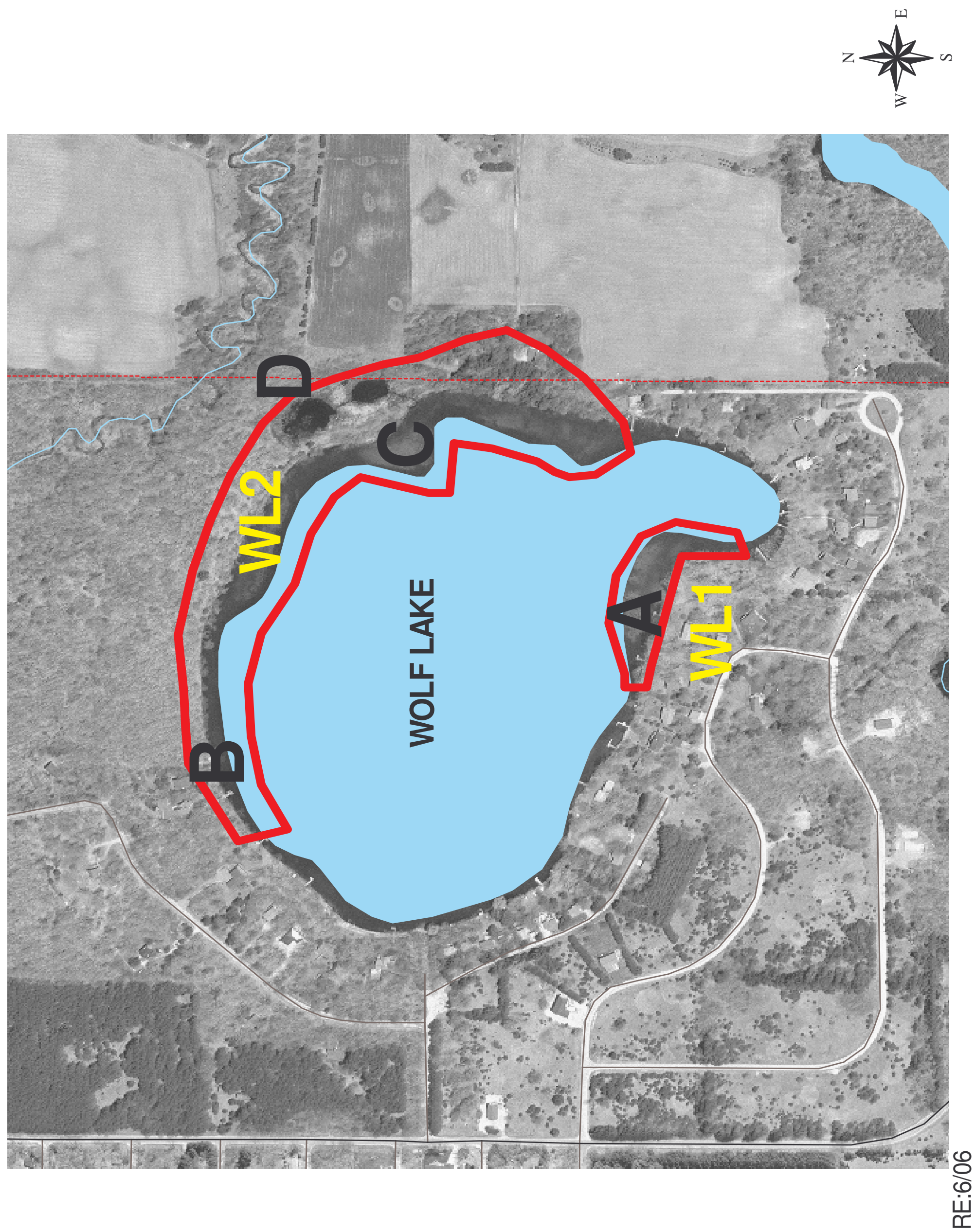
Besides protecting the landward shore areas, preserving the littoral (shallow) zone and its plant communities not only provides essential habitat for fish, wildlife, and the invertebrates that feed on them, but also provides further erosion protection and water quality protection.

Field work for a critical habitat area study was performed on June 6, 2006, on Wolf Lake, Adams County. The field study team included: Scot Ironside, DNR Fish Biologist; Deborah Konkel, DNR Aquatic Plant Specialist; and Reesa Evans, Adams

County Land & Water Conservation Department. Input was also gained from Terry Kafka, DNR Water Regulation; Jim Keir, DNR Wildlife Biologist; and Buzz Sorge, DNR Lake Manager. Areas were identified visually, with GPS readings and digital photos providing additional information.

Figure 51: Critical Habitat Areas on Wolf Lake

Figure 50: Critical Habitat Areas--Wolf Lake



Area WL1

This area extends along approximately 425 feet of the southeastern shoreline of Wolf Lake, up to the ordinary high water mark. Sediment includes marl, sand, silt and mixtures thereof. 65% of the shore is wooded; 5% is native herbaceous cover; the remaining shore is hard structure and rock riprap. Large woody cover is common for habitat. With only a little human disturbance along this shoreline, the area has natural scenic beauty.

Figure 52: Photo of Point A in Area WL1, Wolf Lake

This area of large woody cover, emergent aquatic vegetation, submergent and floating vegetation provides spawning and nursery areas for many types of fish: northern pike; largemouth bass; rock bass; bluegill; pumpkinseed; yellow perch; crappie; bullhead; and other panfish. All of these fish also feed and take cover in these areas. No exotic aquatic wildlife was noted in this area, i.e, no carp, smelt or rusty crayfish were seen. Filamentous algae were found at this site.

Muskrat and mink are also known to use this habitat for cover, reproduction and feeding. Seen during the field survey were various types of waterfowl, songbirds, and turkey. Frogs and salamanders are known to use these areas for shelter/cover, nesting and feeding. Turtles and snakes also use these areas for cover or shelter in this area, as well as nested and fed. Upland wildlife feed and nest here as well. Since human disturbance is absent in WL1, it provides high-quality habitat for many types of wildlife.

Six types of emergents were found here. Emergents provide important fish habitat and spawning areas, as well as food and cover for wildlife. Two species of floating-leaf plants were present here. Floating-leaf plants provide cover for fish and invertebrates, as well as help dampen waves to protect the shore. Filamentous algae were present. Eighteen species of native submergent plants were also at this site. Such a diverse submergent community provides many benefits. One exotic invasive plant was found in this area (submergent).

Figure 53: Sandhill Crane in Wolf Lake Wetlands

Area WL2

This area extends along approximately 1900 feet of the northern shoreline and landward from the shore to cover the deep marsh and sedge meadow wetlands located near the shore. Sediment includes marl, peat, silt and mixtures thereof. 46.43% of the shore is wooded; 14.28% has shrubs; 20% is native herbaceous cover. The remaining shoreline is rock, cultivated lawn and hard structure. Large woody cover is abundant for habitat. With no human disturbance along this shoreline, the area is has natural scenic beauty.

The abundant large woody cover, as well as emergent aquatic vegetation, submergent and floating vegetation, provides spawning and nursery areas for many types of fish: northern pike; largemouth bass; bluegill; pumpkinseed; yellow perch; crappie; bullhead; suckers, other panfish. These fish also feed and take cover in these areas. No exotic aquatic wildlife was noted in this area, i.e, no carp, smelt or rusty crayfish were seen. No shore development was present.

Seen were various types of waterfowl and songbirds, as well as turtles and snakes. A pair of eagles has nested here for the past several years. Frogs were heard. This wildlife nests and feeds here, as well as using the vegetation for cover or shelter. Downed logs serving as habitat were also seen. Muskrat and mink are known to use WL2 for cover, reproduction and feeding. Upland wildlife feed and nest here as well. Since human disturbance is absent in WL2, it provides high-quality habitat for many types of wildlife.

Figure 54: Photo of Point B, Area WL2, Wolf Lake

Eagle's Nest

Figure 55: Photo of Point C, Area WL2, Wolf Lake

Figure 56: Photo of Area D, Area WL2, Wolf Lake

No threatened or endangered species were found in this area. Three exotic invasives, *Myriophyllum spicatum* (Eurasian watermilfoil), *Phalaris arundinacea* (Reed Canarygrass) and *Potamogeton crispus* (Curly-Leaf Pondweed), were found in this area. Filamentous algae were found, especially near the shores.

10 emergent species were present at WL2, including *Caltha* (Marsh Marigold); *Eleocharis* (spikerush), *Iris versicolor* (Blue-Flag Iris), *Juncus* (Rush), *Sagittaria* (Arrowhead), *Scirpus* (Bulrush), *Sparganium* (Burreed), *Spirea* (Meadowsweet) and *Typha* (Cattail). Emergents provide important fish habitat and spawning areas, as well as food and cover for wildlife.

Three species present were floating-leaf rooted plants: *Nuphar variegata* (Yellow Pond Lily); *Nymphaea odorata* (White Water Lily) and *Polygonum amphibium* (Water Smartweed). Floating-leaf vegetation provides cover and dampens waves, protecting the shore. The remaining aquatic vegetation was submergent: *Chara* spp (Muskgrass), *Elodea canadensis* (Waterweed); *Najas guadalupensis* (Southern Naiad), *Nitella* spp (Stonewort), *Potamogeton crispus* (Curly-Leaf Pondweed), *Potamogeton diversifolius* (Water-Thread Pondweed), *Potamogeton foliosus* (Leafy Pondweed), and *Potamogeton gramineus* (Grass-Leaved Pondweed). Such a diverse submergent community provides many benefits.

Three invasive plants were found at WL2: one emergent and two submergents. Also present at this site were nine other emergent aquatic plants, three floating-leaf plants and at least eight submergent species.

Recommendations for preserving these areas resulted from this field survey and analysis. They included:

(1) Maintain current habitat for fish and wildlife.
(2) Do not remove fallen trees along the shoreline nor logs in the water.
(3) No alteration of littoral zone unless to improve spawning habitat.
(4) Seasonal protection of spawning habitat.
(5) Maintain snag/cavity trees for nesting.
(6) Maintain or increase wildlife corridor.
(7) Maintain sedge meadow and deep marsh areas.
(8) Maintain no-wake zone.
(9) Protect emergent vegetation for habitat and shoreline protection.
(10) Removal of submergent vegetation for navigation purposes only.
(11) Seasonal control of Eurasian Watermilfoil and Curly-Leaf Pondweed by using control methods specific for exotics.

(12) Minimize aquatic plant and shore plant removal to maximum 30’ wide access/viewing corridor. Leave as much vegetation as possible to protect water quality and habitat.
(13) Use forestry best management practices.
(14) No use of lawn products.
(15) No bank grading or grading of adjacent land.
(16) No pier construction or other activity except by permit using a case-by-case evaluation.
(17) No installation of pea gravel or sand blankets.
(18) No bank restoration unless the erosion index scores moderate or high.
(19) If the erosion index does score moderate or high, bank restoration only using biologs or similar bioengineering, with no use of riprap or retaining walls.
(20) Placement of swimming rafts or other recreational floating devices only by permit.
(21) Maintain buffer of shoreline vegetation.
(22) Maintain aquatic vegetation in undisturbed condition for wildlife habitat, fish use and water quality protection.
(23) Post landing with exotic species alert and educational signs to prevent introduction and/or spread of exotic species.
(24) Maintain no motor designation.

Figure 57: Wolf Lake in Winter 2005

FISHERY/WILDLIFE/ENDANGERED RESOURCES

A 1948 fishery inventory of Wolf Lake described it as "a small bass lake, fertile, hard water, moderate plankton, with heavy fishing pressure." Bluegills were the most abundant fish found then. At that time, it was also recommended that trout no longer be stocked in Wolf Lake.

Stocking of fish by the WDNR in Wolf Lake started in 1937 with smallmouth bass, perch and bluegill. Annual stocking of bluegills, crappie, largemouth bass and/or perch continued through 1942. Stocking resumed in 1946 with sunfish and largemouth bass and continued through 1949. A few brown trout were stocked in 1991.

A 1963 fish inventory found both largemouth bass and bluegills abundant, with pumpkinseed also common. Rock bass, black crappie and green sunfish were present, but not in great numbers. Yellow perch were scarce. By 1973, yellow perch, black crappie and green sunfish were found in greater numbers, but pumpkinseed and rock bass had become scarce, as were brown bullheads and northern pike. Largemouth bass and bluegills continued to be found in large numbers. Inventories repeated in 1982 and 1996 noted this trend continued: largemouth bass and bluegill found in great numbers, but bullheads, perch, rockbass and pumpkinseed still scarce.

Fish cribs were installed in the lake in 1997 to encourage reproduction.

Muskrat and mink are also known to use this habitat for cover, reproduction and feeding. Seen during the field survey were various types of waterfowl, songbirds, and turkey. Frogs and salamanders are known to use this area for shelter/cover, nesting and feeding. Turtles and snakes also use this area for cover or shelter in this area, as well as nested and fed in this area. A pair of eagles has nested here for the past several years. Sandhill cranes have also nested on Wolf Lake. Upland wildlife feed and nest here as well.

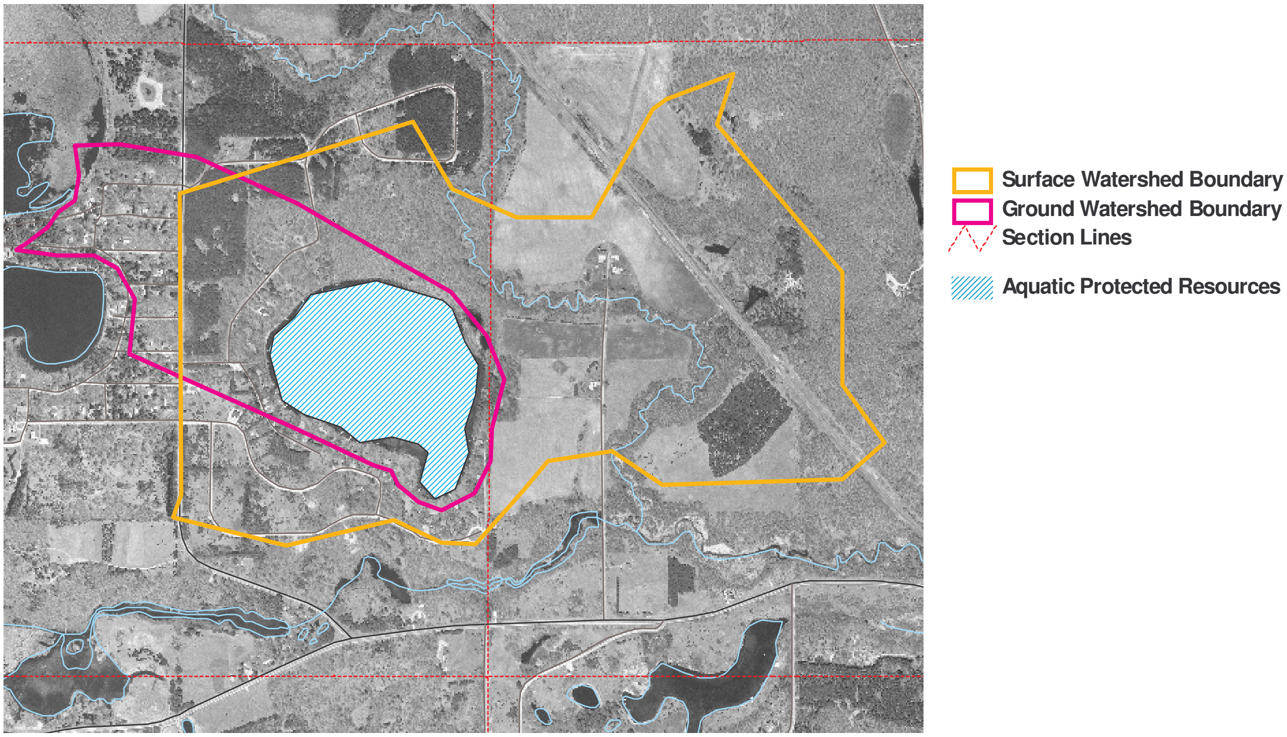
Figure 58: Common Fish in Wolf Lake—Largemouth Bass

Figure 59: Sandhill Crane Nest at Wolf Lake

Red Banded Killifish was the only endangered or threatened species reported around or in Wolf Lake. It was reported as scarce in a 1996 fish survey.

Figure 60: *Fundulus diaphanous* (Banded Killifish)

Figure 61: Location of Endangered/Threatened Species In Wolf Lake Area*



RE:5/05, revised 6/06

*information courtesy of Wisconsin Department of Natural Resources

Figure 62: Another Part of Wolf Lake's Shores

RESOURCES

Bryan, B., B. Charry. 2006. Conserving Wildlife in Maine's Shoreland Habitats. Maine Audobon Society.

Carlson, R.E. 1977. A Trophic State Index for Lakes. Limnology and Oceanography 22:361-369.

Dennison, W., R. Orth, K. Moore, J. Stevenson, V. Carter, S. Kollar, P. Bergstrom, R. Batuik. 1993. Assessing Water Quality with Submersed Vegetation. Bioscience 43(2):86-94.

Engel, S. 1985. Aquatic Community Interactions of Submerged Macrophytes. Wisconsin Department of Natural Resources Bulletion #156.

Frankenberg, J. Land Use and Water Quality. Purdue Extension Publication ID-230.

James, T. 1992. A Guidebook for Lake Associations. The International Coalition for Land and Water Stewardship in the Red River Basin, Minnesota.

Kibler, D.F., ed. 1982. Urban Stormwater Hydrology. Water Resources Monograph 7. American Geophysical Union.

Krysel, C, E.M. Boyer, C. Parson, P. Welle. 2003. Lakeshore Property Values and Water Quality: Evidence from Property Sales in the Mississippi Headwaters Region. Report to the Legislative Commission on Minnesota Resources.

Lillie, R.A., J.W. Mason. 1983. Limnological Characteristics of Wisconsin Lakes. Department of Natural Resources Bulletin No. 138.

Nichols, S. 1998. Floristic Quality Assessment of Wisconsin Lake Plant Communities with Example Applications. Journal of Lake and Reservoir Management 15(2):133-141.

Nichols, S., S. Weber, B. Shaw. 2000. A Proposed Aquatic Plant Community Biotic Index for Wisconsin Lakes. Environmental Management 26(5): 491-562.

Shaw, B., C. Mechanich, L. Klessing. Understanding Lake Data. UW-Extension Publication SR-02/2002-1M-525, 2000.

Terrell, C., P. Perfetti. 1989. Water Quality Indicators Guide: Surface Waters. United States Department of Agriculture Publication SCS-TP-161.

Wagner, C., J. Haack, R. Korth. Protecting Our Living Shores. 2003. Shoreland Stewardship Series #3 WDNR Publication WT-764-2003. UW-Extension, Wis. Lakes Partnership, WDNR, Wisconsin Association of Lake & River Alliance of Wisconsin.